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GRAFTING FRENCH VINES WITH AMERICAN STOCK.

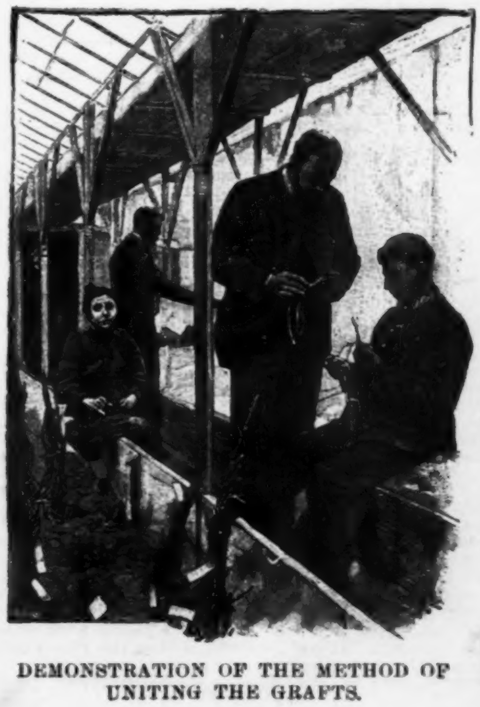
In each hamlet of France white posters affixed to the walls of the town hall make known to the population, in the name of the prefect, the dates in the month of March in which the Professor of Agriculture will give a free course of six days' instruction in grafting the vine near some of the large cities. The heritage of the young viticulturist is an ungrateful earth, vineyards disappearing inch by inch before the dreaded phylloxera, and presses for wine making dropping to pieces for lack of use. They know that the professors for fifteen years have taxed their ability to the utmost in wrestling with the dreaded foe which menaces the vineyards of France with a disaster without parallel, and they know that the disinterested counsels of these learned men are full of wisdom as they give a *resumé* of their experience acquired both by science and practice. The course comprehends the theory of grafting, the practice of grafting, the care to be bestowed in the nursery, the planting of the grafted vines and a visit to the nursery. A diploma is awarded to good scholars.

This course is given in a number of the departments of France, the details of instruction varying somewhat according to the section of the country. Our illustrations and description are taken from the district of Nevers, where the instruction is given by M. Mancheron. Before describing the operations it is necessary to speak of the phylloxera in this district. Though the results of the ravages of the phylloxera are the same, the methods of combating the evil vary. The disaster is spreading. 800, then 1,000, then 2,000 hectares of vineyards, out of 11,000 or 12,000, have almost disappeared. M. Mancheron, with a small annual appropriation, 9,000 francs in all, half paid by the government and half by the department, has undertaken the extraordinary task of creating a departmental nursery, where he directs the culture of the best varieties of the vine on which the new grafts are made. Our first illustration represents these vines strung on poles 6 or 7 meters high, somewhat resembling hop poles. An assistant at the left is cutting the vines near the ground, so as to leave an "eye" in the stump. A large quantity of branches, 6 meters or longer, are thus obtained. The cuttings being too long to transport readily, are cut up into lengths of one meter, just below the bud or eye. The cuttings are bound up in bundles of one hundred and carried to a shed where they are untied and laid horizontally on a bed of sand, which must be absolutely without any vegetation. The sand must also be very dry, as the bud or eye must not have the slightest encouragement to open, as then the success of the graft would be imperiled. If kept dry, the graft can be preserved ten years. The professor attends personally to the instruction of the novices, who consist of apprentices from the primary schools and also of proprietors of a certain age, desirous of being instructed in the operations of grafting themselves in order that they may be able to superintend the work of their men.

CUTTING GRAFTS FROM AMERICAN VINES.

At Nevers an old outhouse, a dependence of the national foundry, is used to store the utensils and for a place in which to give demonstrations. On tables are pulverizers for the insecticide *bouille bordelaise*, on the walls are pails for carbon bisulphide, and around the room are scattered utensils which strike the newcomer with wonderment. The students are given positions which they hold during the course. A blackboard is freely used to assist in explaining obscure points. "Attention!" says the professor, after the manner of a captain. "Take your pruning

STUDENTS CUTTING THE GRAFTS.



DEMONSTRATION OF THE METHOD OF UNITING THE GRAFTS.

shears in your right hand." Forty right hands seize their shears, and, on a second order, forty left hands seize a branch from a pile before proceeding to cut the tendrils. "Cut the tendrils." Forty shears snip the branch. Then the shears are laid aside and the grafting knife is taken up and the sloping splicing cut is given. The operation of cutting and slitting does not require more attention than the joining of the two kinds of vine. This operation requires the professor to give personal instruction to each student. The branch is held immovable by the left hand, the arm being held close to the body to insure the greatest possible resistance. The right must have great agility at this point to perform the delicate operation of uniting the graft. The operations to this point comprise all that the jury, which meets on Saturday, requires to give a student a certificate or diploma that he can make a graft. A good grafter can earn from 4 to 5 francs a day, while the other workers can only obtain 2½ francs. We will now follow the graft in its different operations. M. Mancheron prefers to place the grafts as soon as made. In one method of operating in a greenhouse, where they are ranged in lines in wet sand heated to 30° C., vegetation begins and a month is gained. The graft is gradually prepared to stand the temperature of the outer air, new roots are soon formed and the plants are ready for planting. In the departmental nursery the students are the workers, they being still under the control of the same professor who taught them the rudiments of their art. The students now become real workmen and graft to some purpose. Immense bundles of the American-French vines are sent away; thus good grafted plants with roots are sold at from 5 to 10 centimes without costing the department anything. The new grafts are bringing about a gradual improvement in the vineyards of France. For the cuts and the foregoing information we are indebted to *L'Illustration*. In brief, the French process is to unite a good variety of the French vine with a phylloxera-proof vine, such as the American *raphia*. The graft is made and the two varieties united, after which a root is formed on the American vine, so that the result is the original French grape on an American phylloxera-proof root.

RECENT INVESTIGATIONS AND IDEAS ON FIXATION OF NITROGEN BY PLANTS.*

By H. MARSHALL WARD.

THREE totally different, though convergent, scientific controversies have arisen during the latter half of the present century concerning the role played in nature by nitrogen, as met with in the air, rain and soil, free or combined, in connection with the ordinary plants of agriculture and forestry; and, quite apart from their real relations to one another, these three controversies have at times been somewhat confused in their issues.

One of these controversies turned on the question of the transformations of combined nitrogen, as met with in the forms of ammonia, nitrites and nitrates, and as organic compounds of nitrogen, resulting from the decomposition of the remains of living beings—plants and animals—in the soil. The outcome has been the proof that oxidations and deoxidations of these compounds are intimately bound up with the physiological activities of living organisms, especially bacteria in the soil; the investigations of Giltay and Aberson, and Winogradsky's brilliant researches especially, have brought what had long been regarded as purely chemical problems into the domain of biology. "Nitrification" and "denitrification," to use the current terms, are phenomena incorporated with those of fermentation, respiration, etc., and therefore involve biological science for their elucidation.

Another of these controversies turned on the question whether the free nitrogen which forms so large a proportion of that huge gaseous ocean, the atmosphere, can be again directly employed by green leaves, and built up as combined nitrogen in plants; or whether, once having been disengaged from organic and other compounds, and passed into the air as gaseous nitrogen, it is forever lost, except in so far as electric discharges and other energetic physical and chemical processes force this relatively inert element into combinations, which the rain then brings down as inorganic salts, and so help to restore the balance of nitrogenous substances in the soil.

This controversy, a long and involved one, started and for some time continued as a peculiarly chemical question, has passed through various phases and branched out into several subsidiary controversies, if we may so term them.

Thus the alleged "fixation" in the soil, especially investigated by Berthelot and Andre, became a scientific question apparently on definite lines of its own, and (so far as any such question can be independent) independent of the question whether ordinary green leafed plants, such as peas, lucerne, wheat, etc., can assimilate the free nitrogen of the atmosphere by processes more or less comparable to those by which they are known to assimilate the carbon they wrench from the carbon dioxide of that gaseous environment.

The latter question, again, became a divided one, chiefly owing to assertions that green leaves could directly assimilate the ammonia, if not the free nitrogen, of the air, and some time was occupied in arriving at the conclusion that ordinary green plants do not directly assimilate or fix either the gaseous ammonia or the free nitrogen of the atmosphere. This conclusion, in opposition to that arrived at by Ville, was regarded as so thoroughly established by the experiments of Boussingault and of Lawes, Gilbert and Pugh, that it has been definitely accepted and taught for many years—and rightly so, from the evidence to hand.

The third of the three controversies referred to at the outset is the more recent one concerned with the question whether certain of the higher green leafed plants, particularly those known as leguminous plants (such as peas, beans, clovers, vetches, lupins, robinia, etc.), when living as they normally do in symbiotic association with certain microscopic and essentially parasitic fungoid organisms which invade their roots, are differently placed from other green plants as regards the power of "fixing" and assimilating the free nitrogen of the atmosphere.

* From *Nature*.

The present position of opinions on this last and most remarkable controversy is the subject of this article, so far as it can be done justice to in the short space at disposal.

It is now well known that leguminous plants are normally found to have certain nodosities or swellings on their roots, and that these swellings are caused by the activity of certain minute organisms which, as the writer of this article first proved, invade the roots from outside, after the manner of a parasitic fungus. The controversy as to the exact nature of these organisms—bacteria, according to Prazmowski, Beyerinck, and others, degraded allies of the Ustilagineæ, or some lower fungus, according to my observations, and the confirmatory evidence of Laurent—in no way affects the truth that these organisms do not kill the plants attacked, or even make them diseased, but incite them to more active life for a time. The evidence on which these organisms (termed "bacteroids") have been taken to be bacteria—their growth in gelatine tubes, staining, and their minute size—is equally in favor of their being lower fungi, and is not sufficiently conclusive. Eventually the nutritious contents of these nodules, with the symbiotic "bacteroids," are absorbed, in whole or in part, by the leguminous plant, and their rich stores of nitrogenous material assimilated by the latter.

The experiments of Hellriegel and Wilfarth, of Lawes and Gilbert, and of others and myself, placed it beyond reasonable doubt that, taking the leguminous plant and its symbiotic organisms together with the pot of soil in which it is grown as a closed system, this system contains more nitrogen at the end of several weeks than can be accounted for by the nitrogen in the soil and the seed at the commencement of the experiment; and this was true in cases where careful precautions were taken to prevent the addition of any nitrogen further than the free nitrogen of the air. The only legitimate conclusion was that somewhere, and somehow, the system fixes free nitrogen from the air.

This matter has been since carried further, however, by Laurent and Schloesing, who, by growing various plants in an air-tight apparatus under such perfect control that they could analyze the quantity of nitrogen both in the plant and soil, and in the purified air, showed that the gain of nitrogen in the former during the progress of the experiments is balanced by a corresponding loss in the latter. They further showed that only two kinds of plants could thus "fix" the nitrogen of the air. These are leguminous plants, and certain lower algæ (perhaps mixed with bacteria) or allied forms. This fixation only occurs under certain definite conditions, moreover. The leguminous plants must be infected with the symbiotic "bacteroids," and the algæ must be exposed freely to the air and light in the apparatus, even a thin layer of the sterilized sand employed sufficed to stop the action of the algæ.

Laurent and Schloesing found no fixation in the case of artichoke, oats, tobacco, mustard, cress, or any other plants experimented with; and their experiments, taken as crowning the edifice of evidence accumulated by them and numerous other observers, have been fairly regarded as proving that leguminous plants, at any rate, and perhaps certain lower algæ, do somehow "fix" the free nitrogen of the atmosphere and assimilate it.

Koch and Kossowitsch have recently claimed to confirm the above results of Laurent and Schloesing with algæ, and it should be mentioned that Frank had previously stated that such fixation by lower cryptogams occurs. Unfortunately we are as yet uninformed what species of algæ are exactly concerned here, and no one has cultivated them pure and confirmed the results.

It will be noticed that, so far, all that is established is that the infected leguminous plants and the algæ of sorts *plus* the known soil (usually sterilized sand to which known additions are made), somewhere and somehow gain in nitrogen at the expense of the free nitrogen of the atmosphere.

Now come the other aspects of the controversy, which is raging chiefly around the question as to exactly where and how this gaseous nitrogen is fixed.

Obviously several possibilities could be suggested.

(1) The gaseous nitrogen could be conceived as directly fixed by the plant which gains in nitrogen—as absorbed by the protoplasm of the living cells exposed to the air—*e. g.*, the cells of the leaves of the leguminous plant, or those of the algæ on the surface of the soil. This view is actively maintained by Frank and a few supporters, who go as far as is possible in this direction, and really again raise the old question which originated with De Saussure, and was rightly regarded as refuted by Boussingault and Lawes and Gilbert.

(2) The gaseous nitrogen could be conceived to be fixed in the soil by means of bacteria or lower algæ (we have seen these are left indefinite), and, when it has been converted into nitrogenous compounds of some kind in the soil, eventually absorbed by the roots of the leguminous or other higher green plant in the ordinary course of events. The principal champion of this view is Berthelot, who claims to have proved that certain soil bacteria, and also the organisms of the leguminous root nodules, have the power of fixing the free nitrogen of the air, and so enriching the soil in nitrogenous compounds. In this connection, of course, the whole question of nitrification and denitrification in the soil will no doubt be involved with the question of the fixation of free nitrogen from the atmosphere.

(3) The fixation of the atmospheric nitrogen could be conceived of as a powerful act of the machinery of the leguminous plant, urged to the necessary expenditure of energy by the stimulating action of the symbiotic organism in its roots. This view, held especially by Hellriegel, Prazmowski, and others, is also shared by Frank, who believes that it is only in their being thus stimulated to greater activity that the leguminosæ differ from many other plants, which, he says, also fix the atmospheric nitrogen directly, but to so much less an extent that the experimental proof of their power to do it is far more difficult.

(4) Another possible view is that the root organisms act merely as accumulators of nitrogenous material, which has been derived from atmospheric nitrogen fixed and combined in the soil, by physical or chemical processes, or in the open ground by the action of soil organisms; and the leguminous plant benefits by devouring (if we may employ this word) the bacteroids eventually, and profiting by their stores of nitrogenous material.

Let us now take these four possibilities in order, and examine them a little more in detail.

The first view rests almost entirely on the statements of Frank, of Berlin, who brings forward a number of experiments which in his opinion show that many higher plants, in addition to the leguminosæ, are capable of directly assimilating the free nitrogen of the atmosphere. For instance, Frank gives results showing that oats, buckbeans, spurrey, turnips, mustard, potatoes, and Norway maple are all capable of fixing atmospheric nitrogen.

Most of Frank's experiments were made in the open air, the pots of plants being simply sheltered from rain; but in some cases, he affirms that he got positive increase of nitrogen with mustard plants under bell jars, properly shut off from the outer air, and through which purified air was drawn.

Apart from these latter, and in spite of Frank's assertion that the quantities of combined nitrogen in the air are so immeasurably small that they may be neglected, it seems fair to object that, in the present state of science, we cannot trust experiments in the open air to decide such a point; while with regard to the experiments with mustard, it must not be forgotten that not only the old results of Boussingault and Lawes and Gilbert are entirely and emphatically opposed to them, but the exceedingly careful recent experiments of Schloesing and Laurent, made with all modern appliances and methods, showed the contrary—no signs of fixation of nitrogen could be obtained in oats, tobacco, cress, mustard, cabbage, spurrey, and potato, the very plants Frank used.

Frank replies that completely normal plants cannot be grown under such closely covered glass vessels as these experimenters use, but he accepts their positive results in all cases. Frank's contention is that the plant must be very vigorous, and near its maturing point, before it has power to energetically seize and "fix" the atmospheric nitrogen; but (without denying that it is possible that the utmost vigor may not be as yet attainable under the conditions necessary for culture in closed glass receptacles of limited capacity) it is impossible to overlook the danger that in experiments in the open air, the time which must necessarily elapse before Frank's critical period of maturity on the part of the plant is reached is long enough for all sorts of disturbing influences to come in, especially if any kind of "fixation" in the soil, such as Berthelot asserts, really occurs; the root hairs would take up, and the plant absorb nitrogenous bodies as fast as they were formed in the soil around them, while there would be ample time for the development of many generations of micro-organisms in the medium.

In view of the tenacity with which the belief in a direct absorption of atmospheric nitrogen is cherished by many foresters and agriculturists, it seems imperative that critical experiments should be persevered in; as matters stand, we cannot accept Frank's position as proved, or even as rendered probable.

The possibility mentioned above as an explanation of the danger of accepting Frank's results would be rendered a certainty if the recent researches of Laurent and Schloesing, Koch and Kossowitsch, and Berthelot, in part supporting earlier statements by Frank himself, turn out to have been properly interpreted.

Laurent and Schloesing—and their results are confirmed by Koch and Kossowitsch—declare that sterilized sand, devoid of nitrogenous material, when covered with a growth of certain green and blue-green algæ, probably mixed, however, really does "fix" the atmospheric nitrogen, and gains in nitrogen compounds, but only if the algal growth is freely exposed to the atmosphere in the closed chambers employed. These statements confirm earlier, but less definite, experimental results by Frank; and the latter has recently expressly stated that certain fungi—*e. g. Penicillium cladosporioides*—can flourish in a medium to which no nitrogen but that of the atmosphere has access.

Berthelot goes further, and claims to have established that several species of soil bacteria and fungi, including the fungoid organism of the leguminous tubercles cultivated separately, can "fix" free nitrogen; and if the analyses of the small quantites of materials in his flasks survive the criticism of the chemists, it seems difficult to refuse credence to the views he puts forward; but, as in most of these cases, it is the enormous difficulties of analyses which lie at the root of the matter.

Moreover, different observers differ considerably on this question. Beyerinck, while regarding it as probable that the nodule organisms "fix" atmospheric nitrogen, admits that he does not prove it; and in Laurent's special investigation into this question, he left it also uncertain; while Immendorf failed to satisfy himself that these organisms can flourish without organic compounds of nitrogen; and Frank insists that they do not thrive at all without organic nitrogenous food materials. Moreover, it must not be overlooked that other observers, *e. g.*, Gautier and Drouin, have given evidence pointing to possible phenomena of "fixation" of nitrogen by compounds of iron and other substances clinging to particles of the sand employed, which may interfere with the accuracy of conclusions drawn from experiments where sterilized soil in the open air is concerned.

When we reflect how very minute these organisms are, and what excessively small quantities of nitrogen they need for their life purposes, we cannot be surprised at the difficulties met with in these investigations. But, however far from proved we may regard the question of fixation of free nitrogen by soil organisms, it is perfectly clear that here is a most pressing question for further experimental research, and agricultural and forest practice are alike keenly interested in having the question definitely answered.

The third possible view—that the leguminosæ are able to force free nitrogen into combination with other elements, owing to the energetic action of their protoplasmic machinery stimulated by the symbiotic fungoid organism—deserves more consideration than may at first sight appear, especially to those who are not familiarized with the remarkable phenomena of symbiosis generally.

In the first place, the fact that leguminous plants amply provided with the root nodules *do* "fix" the atmospheric nitrogen, under conditions in which the same plants devoid of the nodules fail to increase their supplies of nitrogen, is far better established than any of the other cases discussed, and must now be accepted

as proved by the experiments of Frank, Hellriegel, myself, Lawes and Gilbert, and especially by the recent splendid investigations of Laurent and Schloesing.

It is true that Frank says the symbiosis is not absolutely necessary for the fixation to proceed, but even he declares that the leguminosæ are stimulated to greater powers of nitrogen fixation by the nodule organisms.

A curious and significant confirmation of the symbiosis theory comes from the experiments of Nobbe, Schmid, Hiltner, and Hotter, who find that *Elæagnus* plants, the roots of which develop nodules due to the invasion of a fungus totally different from the one causing the leguminous nodules, also "fix" and assimilate the free nitrogen of the atmosphere, as shown by their growing and flourishing much better and more rapidly than *Elæagnus* plants side by side with them, but not infected with the root organism. It will be interesting to see if further research shows similar results with any of the physiologically similar root outgrowths, due to very different fungi, met with in *Taxodium*,

PUTTING THE GRAFTS UNDER COVER.

Podocarpus, *Alnus*, *Juncus*, and many other plants, including some vascular cryptogams.

Now comes the question, in what part of the leguminous plant does the actual "fixation" of the free nitrogen occur? Frank stands practically alone in claiming the leaves to be the organs concerned. Nearly all other observers regard the roots as the region, and the nodules themselves as the actual seat of fixation.

Kossowitsch has even attempted the heroic task of deciding between leaves and roots, by inclosing the former or the latter respectively in air-tight receptacles, shut off from the non-inclosed parts, in which gases devoid of nitrogen were circulated. He could not always keep the apparatus perfectly gas-tight, however, and this and other failures met with in these exceedingly difficult experiments undoubtedly weaken the force of his conclusions that it is in the roots and not in the leaves that the process occurs, though it does look as if the balance of evidence obtained fairly supports his conclusion so far as it goes.

There are facts, however, to be gathered from the microscopic analyses of the root nodules, as furnished by myself and others, which have been in great part overlooked in the discussions on this subject, and which, although not conclusive, seem to support the view that the seat of fixation may be in the nodules themselves. For instance, the nodules are supplied with a regular system of conducting vascular bundles, communicating with those of the roots; then their cells, during the period of incubation of the symbiotic organism, are abundantly supplied with starch; further, the cells in which the fungoid organism is vigorously flourishing are evidently exceedingly active, as may be deduced from their large size, brilliant nuclei, protoplasm, and sap vacuole, all of which show signs of intense metabolic activity, lasting for considerable periods. The fact that the sap expressed from these active tissues is alkaline has been interpreted as in accordance with Loew's suggestion that the living protoplasm, in presence of an alkali and free nitrogen, can build up ammonium nitrite, or some similar body. Be this as it may, there can be no question as regards the infected nodule cells being centers where intense physiological activity is going on; and it seems impossible to avoid the conclusion that the vascular supplies from the roots into the nodules bring to these cells water in which various salts, carbo-hydrates, etc., are dissolved, and carry off from them the soluble products of metabolism.

Presumably these products of metabolism include nitrogenous bodies.

In the ordinary course of events, theory teaches that these nitrogenous bodies—*e. g.*, amides, preceded by simpler compounds—are built up by the machinery of the ordinary living cell protoplasm from carbo-hydrates and nitrates, the energy necessary for the metabolism being derived chiefly (if not entirely) by the oxidation of part of the carbo-hydrates supplied.

This constructive metabolic work of the protoplasm is an act which we cannot explain in detail. We can only dimly perceive that it must be due to some remarkable power the protoplasm possesses—and in virtue of which it is an illimitable machine much more economical in its actions than any apparatus we can construct—of so placing the atoms and molecules of the nitrate, carbo-hydrate, water, etc., with which it works, that they are enabled to undergo movements into which we cannot as yet force them in the laboratory.

The whole matter seems to depend on some peculiar mode of presentment of the atoms and molecules concerned; and we can see no further than that this can be done in the living cell, because the protoplasm is a suitable engine for thus bringing the combining elements into the necessary positions in space.

TRANSPLANTING AND TYING UP GRAFTED ROOTS.

Now, if this is so, there seems no exclusion of the possibility, at any rate, that the cell machinery may be so stimulated into greater activity that it can even force the notoriously inert nitrogen molecules, properly presented, into combinations with other molecules, resulting in the production of nitrites, amides, or similar bodies in ascending order.

The whole matter no doubt resolves itself into some such question of a properly adapted engine sufficiently supplied with energy. The matter seems capable of explanation, in some degree, if we remember that carbo-hydrates and oxygen are present in abundance; the real difficulty is with the machinery, for we cannot as yet picture the exact construction or working of such an engine as physiology nevertheless impels us to suppose the cell protoplasm must be.

It may be remarked, by the way, that the likeness of the living protoplasm to an engine, in the sense implied, may hold good whether the former is an "emulsion," in the sense of the defenders of that hypothesis, or a "structure," in the sense of those who refuse the emulsion hypothesis.

The fourth of the possible views as to the means by which free nitrogen becomes available to the leguminous plant, however, reminds us that, although the evidence points to the stimulated leguminous plant as the best established example of one capable of doing this work, there are other possibilities.

Berthelot's recent insistance that certain soil bacteria can fix free nitrogen, taken with Frank's, Laurent and Schloesing's, and Koch and Kossowitsch's experiments, make it impossible to deny that the above hypothesis as to the powers of the protoplasmic machinery may apply to the cells of some lower organisms, without symbiosis coming into play at all. The remarkable facts brought to light regarding sulphur bacteria and iron bacteria by Winogradsky, and the still more unexpected results this observer obtained with nitrifying organisms, show that the machinery of the cell can avail itself of sources of energy undreamt of by earlier observers. If, by the oxidation of sulphur or sulphureted hydrogen, or of lower iron compounds, or of ammonia, certain of these organisms can obtain the energy necessary to set going machinery capable of so presenting other molecules of the elements they take up to one another that organic compounds result, it is by no means inconceivable that, at the cost of carbon compounds which they oxidize powerfully, the necessary energy can be obtained to force even free nitrogen into combinations.

It is equally conceivable that in the case of the leguminosæ, the symbiotic organism is really more of a parasite (it is necessarily a parasite in some degree) than is assumed in the third view, and that, at the expense of the carbo-hydrates so richly furnished to it by the host plant, the fungoid organism alone supplies the machinery for forcing the nitrogen into combination, and that when it has stored up relatively large quantities, owing to its activity in the incubators—the root-nodules— provided for it by its host plant, and is diminishing in resisting power, the latter at length turns round and absorbs the stores.

The chief objection to this view is that the gains in total nitrogen seem to be greater than would be thus explained, unless the organisms in the soil outside the roots are also fixing free nitrogen.

Such then, put too shortly as regards the numerous experimental facts, are some of the chief ideas agitating the scientific world on this question, a question which, be it emphatically stated, promises to be of more importance to agriculture in the future than any legislation as to prices, etc., that we can conceive; for if it turns out that the acquisition of free nitrogen by the land, or, what amounts to the same thing, the plants growing on it, can be economically promoted, the farmer and forester may have the control of sources of real wealth not yet dreamt of. Unquestionably there is an enormous amount of careful and very difficult experimental work to be done before we arrive at the solution of the various vital questions raised; but the astounding results obtained during the last decade by a few earnest workers promise brilliant results in the future.

WEST INDIAN LIME.

(*Citrus Medica*, L., var. *acida*, Brandis.)

ONE of the most distinct species of *Citrus* is *C. Medica*, which includes the citron, lemon, and the limes. Of the limes there are sweet and sour limes, characterized, according to Roxburgh, by small pinkish flowers, usually four petals, and a perfectly spherical fruit, having a thin skin of a lively yellow color and pale acid juice. Sir Joseph Hooker states that the word lime is promiscuously applied to fruits very different in character, especially in British India, where the sweet limes of various forms are universally spoken of under that name.

The sour lime, although probably introduced from the East Indies, has made its second home in the West Indies, where, indeed, is its present principal area of systematic cultivation. The history of the sour lime is given by Sir Joseph Hooker in the *Botanical Magazine*, tab. 6,745. It was first described by Rumph (*Hortus Amboinensis* ii., p. 107, tab. 29) in 1750, under the name of *Limonellus*, alias *Limotenuis*, or thin skinned lemon. *C. Limonellus* is also described by Miquel, who says it is cultivated everywhere in the Dutch East Indies. The same plant is well figured by Wight as *C. Limetta*, Risso (*Icones*, t. 958), who says it is wild in the Nilgiris. In the West Indies, McFadyen very clearly describes it as *Citrus Lima*, "a thorny shrub with ovate leaves, pentamerous white flowers, small nearly globose yellow fruit, with thin skin, and an abundance of pure acid juice; it is naturalized in Jamaica, forming strong fences." Brandis (*Forest Flora*, Ind., p. 52) rightly places the sour lime of India as a variety of *Citrus Medica*, L.; other authors refer the sour or West Indian lime to *C. Limetta*, Risso, its nearest European representative, but this latter differs in its sweet juice. The botanical position of the West Indian lime as an acid variety of *Citrus Medica*, L., is now established. This small acid lime seems confined to tropical and sub-tropical zones. It does not appear to flourish in Southern Europe, and as already stated, its present headquarters under cultivation are in the West Indies, where in the islands of Montserrat, Dominica, and Jamaica it is commercially

utilized for the production of lime juice and essential oil.

The lime, as already mentioned, yields juice of a singularly pure, acid flavor. The fresh limes are sometimes exported as gathered, or they are pickled in sea water or brine and shipped to the United States. The demand for the fruit in a fresh or pickled state is said to be very limited. Sir Joseph Hooker states: "The lime is a favorite fruit in the West Indies and the Southern United States, the acid being far more grateful than that of the lemon; and it is, hence, universally used for flavoring soups, etc., and in the preparation of many alcoholic and acidulated drinks. In my younger days it was imported in vast quantities into the city of Glasgow, providing an indispensable material for the brewing of the famous Glasgow punch. That it is now so seldom seen, comparatively, is due to the declension of that social and family intercourse that once was so intimate between the great city and the Spanish Main. It is still (with the lemon) the principal source of citric acid."

Lime juice is obtained by compressing the fresh ripe fruits between heavy rollers. This is exported in the raw state or concentrated. The latter is obtained by evaporating the raw juice in copper or enameled iron pans until it is reduced to about one-eighth or one-tenth of the original bulk. When exported it is a dark, viscid fluid of the consistence of treacle. The concentrated lime juice is not used for food purposes, but devoted entirely to the preparation of citric acid, largely in demand by calico printers. From the rind of the fresh fruits there is obtained by a hand process, called "ecuelling," a fine essence of limes exported in copper vessels. A description, with an account of the mode of using the *ecuelle* (a specimen of which was presented to Kew by Mr. Joseph Sturge, managing director of the Montserrat Company in 1892), is given in the *Kew Bulletin*, 1892, pp. 107, 108. The ecuelle is a copper basin furnished on the inside with numerous prominent studs. The instrument is held in the left hand while the fruit, taken singly, is gently rubbed with a circular motion on the studs. This action bruises the oil glands in the rind and the oil flows in small quantities to the bottom of the basin. The process is a slow one and is performed in the West Indies by women and girls. The task per day is measured in fluid ounces. By distilling the raw lime juice a spirit is obtained known as oil of limes. The essence of limes extracted by hand is far more valuable than the oil of limes. The perfume of the latter is injuriously affected by the heat necessary in distillation.

A recent and somewhat full account of the lime industry at Montserrat and Dominica is given by Mr. Consul Galbraith in the United States Consular Reports, December, 1892, pp. 519-522. As these reports are not easily accessible in this country, the following brief summary is given on points not already touched upon: The area under lime cultivation at Montserrat in 1892 is estimated at "1,200 acres, of which about 900 acres are in fruit-bearing trees." The orchards in Dominica are smaller, and with one or two exceptions, the same care is not exercised in the cultivation of the trees, nor in the manufacture of the juice. "The largest crops are gathered in years in which the rainfall is heaviest. The average yield of fruit from an orchard in full bearing would be about 60 to 80 barrels (an ordinary flour barrel is employed in all orchards to gauge the quantity of fruit) from an acre per annum. . . . . A barrel of fruit will yield from six to seven gallons of juice, and each gallon of sound ripe juice contains from 12 to 15 ounces of citric acid." Raw lime juice is preserved in casks and shipped chiefly to the London market. The manufacture of concentrated lime juice consists in boiling the juice in open pans until reduced to about one-tenth of its volume; "it is then a black, viscid fluid containing from 80 to 100 ounces of citric acid per gallon. . . . Concentrated lime juice is principally shipped to the New York market."

Green limes are exported to a small extent only, and to the English market. Pickled limes, in salt water or brine, are invariably sent to Boston. "The average shipments of products of the lime tree from Montserrat for the last five years were as follows: Raw lime juice, 800 puncheons of 120 gallons each; concentrated lime juice, 200 casks of 54 gallons each; green limes, 1,000 boxes; pickled limes, 300 barrels; essential oil, 2,500 pounds."—*Kew Bulletin.*

PLANTING AND MANAGEMENT OF TREES.

MR. WILLIAM THOMPSON, of Clovenfords, writes as follows to the *Scotsman*. One of the lessons in arboriculture that the recent gales have taught is that fine picturesque trees, such as are planted either for ornament or shelter round noblemen's and gentlemen's parks, are bound to come to grief when exposed to such gales as we had last winter, unless greater precautions are taken and more skill shown in preparing the ground before they are planted, in the act of planting itself, and their subsequent pruning. Not only do the trees get blown over, but the park walls near which they stand are all torn into gaps by the roots of the trees that have got under them, or else by the trees falling on the walls. As witness what happened last winter at Drummond Castle, near Crieff, where hundreds of very fine oak and other trees were either blown down or so disfigured by the destruction of their branches as to be no longer ornaments. Any one who will carefully diagnose such a case—as the writer has done more than once—will find that a great many of the roots of such trees run along the ground, very near the surface, where the soil most congenial to their extension is situate, in which position their anchorage power, so to speak, is small compared with what it would have been had said roots been for the greater part one to two feet under the surface of the soil. So much for the roots—now for the branches. These are allowed to extend at their pleasure till they form great, long limbs—very picturesque, and much to be desired, no doubt, but very dangerous for their own safety, in the first place, and equally so for the stability of the whole tree. Every one with the slightest knowledge of mechanics knows that the power of the lever increases in the ratio of its distance from the fulcrum, therefore a long branch brings enormously increased power to bear on wrenching the roots of the tree out of the ground, or, if the roots are able to resist, the branch itself has to succumb, in either case destroying the tree for either shelter or ornament. To mitigate, if not completely to avoid, such disastrous consequences, a different system of planting and pruning should be adopted. The foundation of the wall, after the ground has been well drained, should be laid not less than three feet deep, and should be of concrete up to ground level, so that the roots of the trees should not be able to penetrate it. The whole ground in which the trees are to be planted should be trenched at least two feet deep, the good soil of the surface being placed not less than a foot deep, so as to induce the trees to make all their roots at that depth, and not run along the surface, as they do in most cases when planted in the usual way. This weight of soil over the roots would counteract to a large extent the leverage of the long branches. With regard to the branches themselves, they should have their points cut off when they develop a tendency to take a strong lead. Thus the trees would have more compact heads—not, perhaps, so picturesque from an artistic point of view, but still handsome, shapely trees, no three or four branches of which would put such a strain on the roots as one that is allowed to ramble on at its own will would. What I have proposed will, I think, commend itself to the unprejudiced mind as being founded on reason and the known laws that bear on the question; and it is a very serious one, as many within the last quarter of a century have found to their cost.

RHODODENDRON SCHLIPPENBACHII.*

THIS is a Korean and Manchurian species, with obovate, retuse, undulate leaves, in texture like those of an azalea, produced before or about the same time as the flowers. The young shoots and flower stalks are hairy, the latter intermixed with bracts, most of which fall off as the flowers expand, but of which the inner ones remain. The flowers, as shown in the specimen from which our illustration was taken, are pale rosy-lilac, funnel-shaped, with a broadly expanded five-lobed limb, of which the three upper lobes are marked with dark spots near the base. Stamens ten, unequal in length. It was shown by Messrs. Veitch at the meeting of the Royal Horticultural Society on March 27.—*The Gardeners' Chronicle.*

RHODODENDRON SCHLIPPENBACHII (MAXIMOWICZ)—HARDY SHRUB; FLOWERS PALE ROSY LILAC.

THE DATE PALM.

THE date palm, like the cocoanut, must find a place with the half-dozen trees which are of most value to the human race. It is the type of Phœnix, a small genus of northern Africa, southeastern Africa and tropical Asia. The flower spikes of all the plants of this genus grow from among the long pennate leaves and bear unisexual flowers, the two sexes being produced on different individuals. The flowers have a cup-shaped, three-toothed calyx, a corolla of three petals, their edges valvate in the male and overlapping in the female flower. In the former there are usually six stamens with abbreviated filaments and narrow erect anthers; in the latter there are three distinct ovaries with sessile hooked stigmas. One of the ovaries only develops into a fruit, which is fleshy and one-seeded, that of Phœnix dactylifera being the date.

The date palm is a tree sometimes one hundred to one hundred and twenty feet in height, with a trunk covered with the persistent bases of the leaf stalks and often surrounded at the foot by a dense mass of root suckers. The trees flower in March and April, and as the male trees are generally less numerous than the female, the flowers of the latter are often fertilized artificially. In some parts of India and in Arabia this is done before the flower sheaths expand, an opening being made in the sheath of the female inflorescence, into which a few pieces of the male panicle are inserted. The fruit ripens in the autumn; and through long cultivation a number of varieties, differing in the color, shape, taste and size of the fruit, have been developed in northern Africa and central Arabia, which is supposed to produce the best dates.

The home of this tree is believed to be the whole arid region from the eastern Canary Islands on the west, through the African Sahara, to the lower basin of the Euphrates. The date palm was thought by Brandis to have been introduced into India at the time of the first Mohammedan conquest of Sindh, in the commencement of the eighth century.

The date palm flourishes in the dry regions of northern Africa and western Asia, where it is exposed to excessive heat during the day and not infrequently to frost at night, although it cannot live without a certain amount of moisture in the soil. In Europe it is cultivated in Spain, where it was introduced by the Arabs and where it produces fruit, and on the Riviera, in France and Italy, although it rarely fruits there. In southern Italy, Sicily and Greece, the date palm is now not uncommon, although the climate does not enable it to produce fruit of good quality. On the island of Delos, before Homer's time, date palms sacred to Apollo had been planted; in Syria and Palestine the cultivation of this tree is older than the earliest historical records; and on the southern shores of the Caspian it was also once largely cultivated. It is cultivated and now reproduces itself in Sindh, in the southern Punjab and in the Indian trans-Indus territory. It does not, however, thrive in Bengal, where probably both the heat and rainfall are too great for it.

Not only does the fruit of the date palm supply millions of the human race and their beasts of burden with their chief article of food, but from its leaves the huts of many tribes are entirely constructed. The fiber which surrounds the base of the leaf stalks is manufactured into ropes and coarse cloth, and from the leaf stalks, crates, baskets, brooms and walking sticks are made. The center of the young leaves is eaten as a vegetable, and from the sap, to obtain which, however, the tree must be destroyed, an intoxicating beverage is prepared.

The wood of the date palm is rather light, but is used in house and bridge building, and for various other purposes, although the fruit-bearing trees are so valuable that only the males or trees past the productive age are cut for timber.

The soil and climate of many parts of southern California are well suited to develop the best qualities of this tree, and it is not improbable that the production of dates will soon become an important and profitable California industry.

The date palm was first planted in California nearly a century ago by the Jesuit priests who came into the State from Mexico, and their trees may still be seen in the garden of their mission house at San Diego; and as long ago as 1877 dates raised in California and produced from trees which were only twenty years old were exhibited in San Francisco. An account of the

* *Rhododendron Schlippenbachii*, Maximowicz, in *Bull. Acad. Sc. Petersburg*, xv., 226; Rhododendron Asiæ orientalis, p. 29 (1870).

introduction of the date palm into California, with precise directions for its cultivation and requirements, will be found in the second edition of Wickson's excellent treatise on "California Fruits and How to Grow Them."

The date palm is hardy in some parts of Florida and on the islands of the Georgia coast, and large plants may be seen in the gardens on Cumberland Island, where they have been growing for at least fifty years. The climate, however, of the South Atlantic States is so wet in summer that the date palm will never be cultivated in any part of them except for ornament or as a curiosity.—*Garden and Forest.*

NEW PROCESS OF PRESERVING POTATOES.

DURING a meeting of the Botanical Society of France, last January, Mr. Prillieux, a professor well known in the botanical and agricultural world, pointed out a teratological fact, with specimens in support of it, that closed the session in an interesting and recreative manner. It was a question of some potatoes that had been treated by an able investigator, Mr. Schribaux, with a view to their preservation, and that exhibited an extraordinary budding (Figs. 1 and 2).

It must be known that in this presentation the physiological side was supported by an experiment whose practical consequences deserve some little attention.

Mr. Schribaux, a professor at the Agricultural Institute, has devoted himself to the work of finding, in the selection of the seeds used in agriculture, a method of fixing new or valuable varieties. The duration of the germinative property of such seeds, and many other studies in this direction, have attracted his attention for a long time back. In a slightly different order of things, he set his wits to work to find a process for preventing stored potatoes from germinating, or "sprouting" as it is commonly called. The only method employed for a long time back has been cutting out the "eyes." It is, as well known, necessary to watch the tubers carefully, since the elongation of their buds renders them unfit for consumption.

So, in cultivation, early varieties of potatoes are sought for spring consumption, on the one hand, and then, on another, late varieties, with a view to having vegetables for winter storage. But such conditions are not always met with at wish, and a certain variety that might be esteemed for its qualities as a vegetable or as food for cattle might soon be excluded from cultivation on account of its vegetating much too soon. Hence the difficulty of coming across varieties of potatoes satisfactory for the table or for cattle. With the new process it will be possible to preserve almost all the known varieties for a long period of time.

If it is a question of a small quantity of potatoes, the buds can be skillfully removed with the aid of a knife, but the cuts do not always cicatrize, and an alteration of the tubers is a frequent result thereof. Now, whatever be the amount of the supply, the Schribaux method will be preferable. The method of procedure is as follows:

The quantity of water judged necessary for the bulk of potatoes to be put into it is poured into a wooden receptacle, say a trough or tub. Such quantity having been determined, there is added to it one per cent. of commercial sulphuric acid, marking 66° B. This porportion of acid suffices for the thin-skinned or kitchen garden varieties, but for those of field culture with a relatively thick skin, one can go as far as two per cent. This is a question of feeling one's way, in which rapid progress is made. The potatoes are left in the acidulated liquid for from ten to twelve hours, and are then washed in ordinary water and spread out in order to allow them to dry.

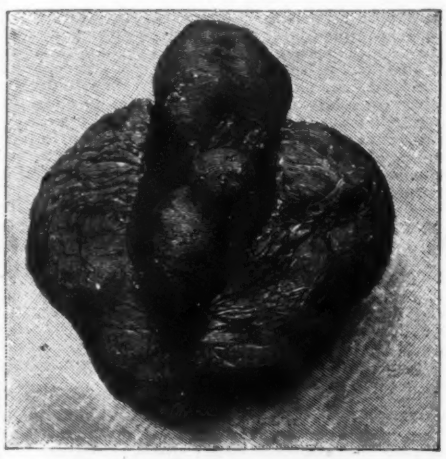
The tubers thus cleaned are freed from all superficial impurities. The suberose tissue of the skin of the potato protects the interior from the action of the acid, while the tender germs devoid of such tissue are eaten by it. When the eyes of the tubers are cut out by hand, the principal bud is indeed removed, but rarely the small lateral buds, which reappear a short time afterward.

As a consequence of the treatment under consideration, small protective cushions of suberose tissue, curious to observe, form in the place not long before occupied by the germs. We have seen such potatoes, a year and a half after treatment, flabby and wrinkled, but not germinating.

Figs. 1 and 2 represent a peculiar case that is sometimes observed in "Richter's Imperator" potato, and that is spoken of at the beginning of this article. It would be scarcely favorable to the process if it became common, but it is purely accidental.

After treatment, this very prolific variety, although not capable of budding externally, nevertheless preserves enough vitality to bud within if it is kept for a long time, and some of the buds soon become transformed into small potatoes. The old exhausted tuber becomes the mother of an interesting family. Has the fact already been observed? We do not know. However, it is a singular effect caused by the application of the process under consideration, and which renders evident the vegetative power of this variety of potato.

Whatever be the reception in store for Mr. Schribaux's method, it cannot be denied that it is a sensible one, and all those who are interested in the progress of agricultural practice will congratulate themselves on making use of it. In this vast domain, the discoveries that are the smallest in appearance often have economic consequences of great value.—*La Nature.*



RICHTER'S IMPERATOR POTATO ACCIDENTALLY BUDDING IN THE INTERIOR OF THE SAME TUBER.

TREE PRUNING.

MORE nonsense has been written on tree pruning and more injury done to woods and plantations by its practice than perhaps any other in the whole range of forest management. Where trees are grown for profit they will, if properly managed, prune themselves, and where for ornament the natural outline is far better than any of the contortions and symmetrical shapes that have been recommended by Brown, Des Cars, and other writers on the subject.

A broken branch may be pruned, a rival leading shoot cut away, or, for good reasons, an ungainly limb amputated, but here all pruning should cease, the practice being wholly wrong and unreasonable, and without one recommendation that could be adduced in its favor. In an economic way the finest plantations of either coniferous or hard-wooded trees in this country are those where the individual specimens are growing so thickly together that the branches are killed outright for fully one-half of their height. Here the stems will be straight and clean, and the timber when converted free from the knots and warping that are so characteristic either of standard specimens or such as have been grown too thinly on the ground.

Every one knows that an oak growing alone or along the margins of a wood is in nine cases out of ten branched almost to the ground, and the bole in consequence rough and ill fitted for any particular constructive purpose, and the same may be said of every other tree, be it hard-wooded or coniferous. Larch and Scotch fir trees growing along the margins of plantations are rough and knotty, and sell at a considerably lower figure when compared with those further in where the branches have been killed back gradually as the trees increased in size.

The same thing is markedly the case in young woods of ash, oak and chestnut, where grown sufficiently thick on the ground to kill off the lower branches, and also to cause the trees to rise straight, clean and tapering. It is a well known fact, too, that the timber of trees so grown is far more elastic and realizes a much higher price than that of the same age, but grown under conditions where pruning might have been a necessity. A case of this kind came under my notice only a short time ago in which one-half of a plantation of hard-wooded trees realized fully one-fourth more than the remaining half. It came about in this way. Both ends and a large patch in the center of the wood had been thinned out severely for the purpose of planting game covert. The trees, standing thinly on the ground, branched out and soon covered the open spaces where underwood had been planted. In thinning the whole plantation the trees on these particular parts were very rough and knotty, and bore no comparison to those where they had been left moderately thick on the ground, and in consequence of which the boles were straight, clean and tapering. This case has special features, inasmuch as the trees over the whole area were growing under exactly similar conditions as to soil, shelter, etc., and were of the same age and species.

Great and irreparable damage has been done to woods and plantations in this country by too heavy thinnings, by commencing the thinning at too early a period, and by adopting the book method of leaving the trees at measured distances apart and a stated number to the acre according to the age of the plantation. Such rules can never be expected to work satisfactorily, the size of trees depending so much on the character of the soil, exposure of the woodland, and other peculiarities of the particular district in which they are planted.

Timely and judicious thinning should never be neglected, but it is the overthinning, whereby branches and knotty trunks are produced and the supposed need for pruning follows, that I wish to deprecate and entirely dissent from. Grow your timber trees so thickly on the ground that the stems are induced to become straight, clean, and branchless for the greater part of their height, and on no account admit sufficient light and air to cause the lower branches to be retained intact, or, in other words, at all times retain an unbroken leaf canopy. The necessity for pruning will then be entirely done away with, and a more valuable class of timber produced. The losses sustained through injudicious planting and the unnecessary and ruinous practice of pruning have taught a lesson that it will be hard to eradicate.—*A. D. Webster, in The Garden.*

[FROM KNOWLEDGE.]

THE PHŒNICIANS, OR PALM TREE PEOPLE.

By J. H. MITCHINER, F.R.A.S.

THE authorities at the British Museum have recently completed an important rearrangement that must prove of the greatest interest to the student of early civilizations.

Some two thousand years before the Christian era, a branch of the Semitic race, emigrating from the direction of the Persian Gulf, settled on the eastern shores of the Mediterranean Sea. The territory occupied was not large, comprising a coast line of some three hundred miles, with an average width of about fifteen. But if the area was restricted in size, in character it was most diversified—a land of mountain and flood, possessing a Lebanon (white mountain) range, its highest peak rising ten thousand two hundred feet above the level of the sea. Seen from the Mediterranean, the distinctive feature of the landscape was the luxuriant palms that everywhere flourished indigenous to the soil. Hence the old pre-Homeric mariners from the Ægean named the country "Phœnicia," or "the Land of Palms," and to the people who inhabited it they gave the name of "Phœnicians," or "The Palm Tree Pepole." Here on this strip of Syrian shore land, on the slopes of its great southern headland Mount Carmel, on the plains of Samaria and Sharon, and on the banks of the Nahr-el-Litani (Lion River), which rises a short distance from the celebrated ruins of Baalbek, collected and prospered beyond precedent, this remarkable branch of the Semitic race.

In character, instincts, and prevailing habits the Phœnicians seem to have been the very opposite of the militant Semitic of ancient history, as the belligerent Babylonian, the cruel Assyrian, or that "bitter and hasty nation" the Chaldæns.* Instead of prosecuting wars of conquest and aggression, they were essentially an industrious and peaceable people, everywhere pioneers of civilization, whose whole genius and energy seemed absorbed in commercial activity. Ships, colonies, and commerce formed the ultimate aim of their political constitution, and their cities, Tyre, Sidon, and Aradus, became centers for the business of the then known world. Phœnician colonies multiplied, extending to Spain and Africa. The present city of Cadiz constituted the ancient Gades of Phœnicia, while Carthage, the daughter of Tyre, was founded on the African coast about 800 B. C. The strength of Phœnicia lay in her navy. "Ships of Tarshish" (ancient *Indiamen*) explored the Adriatic, Ægean, and Mediterranean Seas, sailed through the Straits of Gibraltar, and facing the perils of the Atlantic, effected the circumnavigation of Africa.

According to general testimony it is to the Phœnicians that the world is indebted for the invention of the alphabet†; but whether by them derived from the Egyptian hieratic system or from monumental phonetic symbols remains at present a debatable question. M. De Rouge maintains that the primitive form of almost every Semitic letter can be deduced from its normal hieratic prototype. Doubtless the exigencies of increasing commercial intercourse necessitated some simplification of the imperfect and labored ideographic writing in vogue. A figurative method would dispense with the use of a multitude of tedious phonetic signs. Simplicity was the object to be attained, and we may be quite sure that in the construction of the alphabetical system necessity was the mother of its invention. In common with other Semitic alphabets constructed subsequently on the Phœnician model, it consisted of twenty-two letters, all consonants, and it may be said to have furnished the basis of nearly all other alphabets. The Hebrew is more closely allied to the Phœnician than to any other language; it might, indeed, almost be considered as a dialect of the same tongue. Both alphabets contain twenty-two letters, are without vowels, and the writing reads from right to left. In religion the Phœnicians acknowledged a single deity—one Supreme Power—but the names by which he was known varied with the locality of the temples. El (great) Ram or Rimmon (high), Baal (Lord), Moleck (King), and Adonai (My Lord). As Sun God, Baal had temples at Baalbek, Tyre, Tarsus, Carthage, and Ekron.

The Phœnician relics in the British Museum—the classification and rearrangement of which has just been completed—occupy three rooms in the northern gallery of the building. The archaic Cyprian sculptures (B. C. 650) are for the most part crude in conception and conventional in execution. The country being destitute of marble, the figures are cut from a calcareous limestone, abounding in holes and fossil shells, quite unfitted for purposes of sculpture. Generally speaking, the bass-reliefs are superior in execution to objects in the round. Most of the faces are depicted with remarkably sharp-pointed noses—a feature even more marked in the terra-cottas. Several heads testify to Assyrian and Egyptian influence; while in the later works (B. C. 150) the results of Hellenistic intercourse are manifest in improved artistic execution.

One of the oldest known alphabetical inscriptions is that of Mesha, King of Moab (B. C. 896), and is known as the Moabite Stone. The original is in the Louvre, but an excellent cast will be found in the second room. The stone was discovered by Mr. Klein, a Prussian, at Diban, a village on the east of the Dead Sea. It is of basalt, rounded at both ends, about three and a half feet in height by two feet in thickness and breadth,

* Habakkuk i. 6.

† Lucan *Pharsalia*, iii., V., 220, 222. Lemormant, i., 84. Herod, V., 58. Diod. Sic., V., 24. Pliny, H. N., V., 12, VII., 56. Tacitus, Ann. XI., 14. Eusebius, Chron. Can.

having on one face thirty four lines of inscription, each line about an inch apart. When first seen by Mr. Klein it was in a most perfect state of preservation, not a single piece being broken off. As soon as open efforts were made to secure the treasure, difficulties with conflicting authorities unfortunately arose. Negotiations for its possession were *not* judiciously managed, and ultimately, rather than surrender the stone to the Turkish government, the Arabs determined to destroy it. They lighted a fire round it, and when sufficiently heated threw on its surface cold water and vinegar, thus causing it to crack and split into fragments. Fortunate y a "squeezing" of the inscription had previously been taken by a young *attache* of the French consulate, M. Ganneau. In the woodcut are repro-

THE MOABITE STONE. B.C. 900.

Analysis of the first three lines.

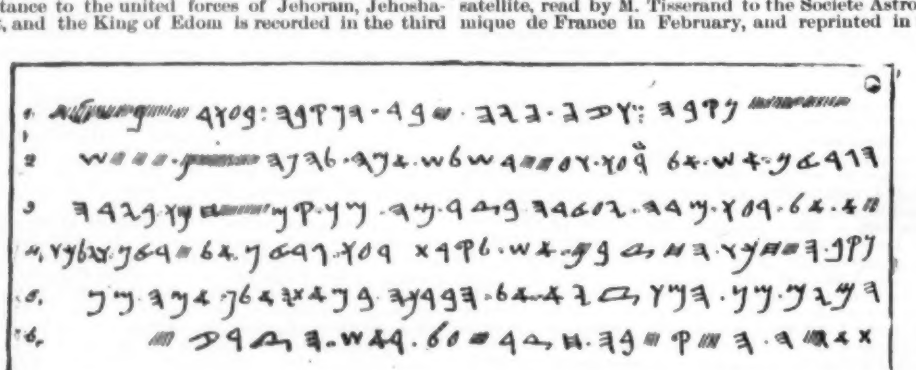
ANoKi MeShA. BeN. KaMoShGaD. MeLeK. Mo'AB [He] D—IBoNI | 'ABI. MaLaK. 'AL. Mo'AB ShLishiN. ShoT V'ANoKi. MaLaK—TI. 'AChaR. 'ABI.

Translation.

1. I am Mesha, son of Kamoshgad, King of Moab, the D-
2. ibonite | My father reigned over Moab thirty years, and I reigned
3. after my father.

duced the first three lines of the inscription. The words are divided from each other by means of points, and the lines or verses by vertical strokes. The whole inscription gives evidence of great fluency, and of long habituation in the use of written characters. Of the undoubted age and genuineness of this interesting relic of antiquity there can be no reasonable doubt. An article by the Rev. A. Lowry on "The Apocryphal Character of the Moabite Stone" appeared in the *Scottish Review* for April, 1887, but the conclusions of the writer are not accepted by other European Semitic scholars.

The stone was erected by Mesha, King of Moab, to commemorate his successes against Omri, King of Israel, and his descendants. This is the same Mesha whose resistance to the united forces of Jehoram, Jehoshaphat, and the King of Edom is recorded in the third



COPY OF INSCRIPTION OF SILOAM.

Translation.

1. *Behold the* excavation! Now this is the history of the tunnel. While the excavators *were using*
2. the pick each to his neighbor, and while there were yet three cubics *to be excavated* the voice of one call-
3. ed to his neighbor, for there was *an excess* in the rock on the right. They arose . . . they struck on the west of the
4. excavation, the excavators struck each to meet his neighbor, pick to pick, and there flowed
5. the waters from the outlet to the Pool for the distance of 1,000 cubits, and . . .
6. of a cubit was the height of the rock at the head of the excavation here.

chapter of II. Kings. Omri became King of Israel B. C. 929. The date of the stone would be about thirty-nine years afterward—that is, 890 B. C. The characters of the inscription are Phœnician of the Moabite dialect. The last four lines are undecipherable. There is great similarity between the Moabite and ancient Hebrew writing, which sufficiently explains how it is that in all biblical references to communications between these people there is no reference on any occasion to an interpreter.

In June, 1880, an important discovery was made in Jerusalem, in the ancient conduit which conveys the water through the hill and under the Mosque of Omar to the Pool of Siloam. The length of the tunnel is one thousand seven hundred and eight feet (five hundred and sixty-nine yards). It is not straight; the passage winds considerably, and reveals several *culs de sac*, showing that the engineering was defective. The inscription (of which a cast will be found in the second room in the British Museum) was found in a niche in the wall, about nineteen feet from the mouth of the tunnel where it opens into the Pool of Siloam. A spot, twenty-seven inches by twenty-six, had been prepared in the solid wall on the right hand side of the tunnel as one enters from the pool, and made smooth to receive the inscription. Being below the water line, before it could be copied it became necessary to lower the water in the conduit.

According to Prof. Sayce, some of the characters, as *waw*, *zayin*, and *Zsadhe*, are more archaic in shape than the corresponding letters in the Moabite inscription. He therefore regards the tunnel inscription as older than the Moabite Stone, and assigns it to the age of Solomon. It is, however, more generally held to date from about 750 B. C., the time of Hezekiah.

We have here the experience in constructing the Mont Cenis tunnel anticipated by two thousand six

hundred years. It is clear the tunnel to the Siloam Pool was commenced simultaneously from both ends; that in consequence of imperfect engineering skill the workmen nearly missed meeting in the center and overlapped, but, directed by the sound of the picks, altered their course until they joined, and the water flowed throughout the conduit. As might be expected from the difficulty in determining many of the half obliterated letters, the translation given by Canon Taylor differs somewhat from that of Prof. Sayce, but the general meaning is in no way affected thereby.

An object of considerable interest in the third room is the large bronze lion weight, of some twenty manehs, engraved with the inscription in Phœnician characters: "Verified in presence of the supervisors of the silver." In the Babylonian room, close by, are several of these weights, evidently of Phœnician manufacture, of from one to ten manehs each. These were found in Babylonia, and are stamped with the official stamp in both Phœnician and cuneiform characters, and were probably cast exclusively for the Babylonian trade. We know the commerce of the Phœnicians was most extensive. They carried on an active export and import trade with Syria, Judea, Egypt, Arabia, Babylonia, Assyria, Mesopotamia, Armenia, Central Asia Minor, Ionia, Cyprus, Hellas, Spain, the Scilly Isles, and the coast of Cornwall. British tin was highly prized, and appears to have secured a monopoly of the markets within Phœnician influence.

There are many other objects and inscriptions also of great interest, as the sarcophagus of the King of Sidon, B. C. 350, the ancient Coptic, Himyritic, Palmyrene, and Hebrew inscriptions, all of which are admirably arranged, and form a deeply instructive chapter in the book of the past.

THE SATELLITE OF NEPTUNE.

The planet Neptune is now in the constellation Taurus, a little to the northeast of Aldebaran; so the following free translation by *Nature* of a paper on its satellite, read by M. Tisserand to the Societe Astronomique de France in February, and reprinted in the March number of *L'Astronomie*, is of interest at the present time.

Less than a month after Galle discovered Neptune* in the place assigned to it by Le Verrier, Lassell suspected the existence of a small satellite, and confirmed his suspicion in 1847. This body is very faint, being of the fourteenth magnitude, and a large telescope is required in order to see it. According to Pickering's photometric observations, its size is about the same as that of our moon, but it is 12,000 times further removed from us, and hence the light we receive from it is very dim.

It is well known that the satellite is in retrograde motion round Neptune, in the same way as the satellites of Uranus. In this respect these two planets on the borders of the solar system strikingly differ from the others. Comparing Neptune with other planets, it would be expected that he would possess more than one satellite, but though many scrutinies have been made with powerful telescopes, particularly that at Washington, no one has found a new attendant.

Neptune's moon is not troubled by the motions of companion satellites, so it ought to present a movement of great simplicity, rigorously realizing the geometrical movement considered by Kepler. In fact, some astronomers have proposed to use the satellite as a means of testing the uniformity of certain movements in the planetary system. The body would constitute a clock of marvelous precision, and with nothing apparently to put it out of order. Accumulated observations have, however, brought to light a singular fact with regard to the satellite's orbit. Five or six years ago, Mr. Marth pointed out that observations made from 1852 to 1883 showed that the orbit was being slowly displaced in a certain direction, its inclination to the plane of Neptune's orbit during this period of thirty-one years having increased by about five degrees—an amount too great to be ascribed to errors of observation. What is more, the observations made by H. Struve with the great refractor at Pulkova, during the last ten years, confirm this variation, both as regards its direction and amount. This being so, the question arises as to the cause of the disturbance.

There can be no hesitation in attributing the change to the oblateness of the planet. The amount of polar compression has not yet been determined by direct measurement, and it will doubtless escape detection for some time to come. This is because the disk of Neptune only subtends to us the small angle of about two seconds of arc, and if the oblateness were, say, 1/100, the ellipticity of the disk would be beyond our perception.

But in order to account for the changes established by observation, it is necessary to take other matters into consideration. If the plane of the orbit of the satellite coincided with the equator of the planet, there would be no reason why this coincidence should not be maintained indefinitely. It seems, however, that the two planes are inclined at a certain angle, and it can be demonstrated that in this case the orbital plane must be displaced with respect to the equatorial one, while the angle between the two remains constant.

If the poles of these two planes are supposed to be projected upon the celestial sphere, the former will move uniformly round the latter in a circle, and by the accumulation of observations for two or three centuries, the position of this circle could be very accurately determined. The center of the circle would be above the north pole of the planet; so by this means it becomes possible to determine the direction of the polar axis—a datum which, as we have seen, cannot be determined directly. The facts at present at the disposal of astronomers are insufficient for the purpose of doing this. It appears probable, however, that the angle referred to is from twenty to twenty-five degrees, and the oblateness less than 1/100. Prof. Newcomb, without going into detailed calculations, has assigned the same cause to the phenomenon.

The fifth satellite of Jupiter, discovered by Prof. Barnard in 1893, ought to exhibit a similar change to that undergone by Neptune's attendant. It does not appear that the four larger Jovian satellites are able to disturb the new one in an appreciable manner; in this case, moreover, the large oblateness of Jupiter must be taken into consideration. But the oblateness produces another effect. It may not modify the position of the orbit of the satellite, because this small body revolves in the plane of the planet's equator, but it may cause the orbit to turn in its plane, and calculations show that it ought to produce a complete turn in about five months. If, therefore, this orbit is not exactly circular, but ever so little eccentric, a time must come when the satellite must appear at a greater distance from the east than from the west limb of the planet, and this is what Prof. Barnard has actually observed. But seventy-five days after these distances must be reversed, for the greater distance should then be from the west limb. It is to be hoped that future observations will decide this point. The effect referred to ought also to be shown by the satellite of Neptune, though it is much less pronounced than the change of the orbital plane; nevertheless, its determination will not be long delayed.

* Neptune was looked for and found by Galle on September 23, 1846; the satellite was discovered by Lassell on October 10 of the same year.

EXTINCT MONSTERS.*

A BRIEF ACCOUNT OF SOME OF THE MOST REMARKABLE FORMS OF ANIMAL LIFE IN THE PAST HISTORY OF THE EARTH.

By STEPHEN BOWERS, A.M., Ph.D., editor of the *Fallbrook Observer*, Fellow of the Geological Society of America, Corresponding Member of the Geographic Society, Philadelphia Academy of Sciences, Member of the Philosophical Society of Great Britain, etc.

THE history of life on this planet previous to the advent of man, which is found recorded in Nature's great stone book, reads more like Oriental fable than like unvarnished truth. The explorations of the geologist have brought to light an ancient fauna that in many respects excels the most feverish human imagination. Their remains have doubtless given rise to stories told in early days of giants, dragons and other monsters. But unlike those fables the intelligent savant has been able to construct a faithful history of the huge animals that walked upon the land, waded in marshes, swam in early seas or navigated the air, but now lie inhumed in the rocks sleeping the sleep of ages. Among reptiles our own North America excels all other lands in singular forms, which also applies to mammals. In presenting a series of articles on the history of extinct monsters, we hope to awaken an interest in the

* From the author's pamphlet.

minds of the young that will lead to the study of forms long since passed, upon which was employed the pencil of divine skill, for each filled a place in the economy of the Creator as important as that of more modern forms. In their study we must consider their environment, as the surrounding fauna; also the flora, the condition of the water, air, climate, etc., and we shall find the same adaptability that is apparent in animals of the present day. Technical terms will be avoided as far as possible, except the names scientists have given to forms we shall describe, with which all students of geology should be familiar.

SEA SCORPIONS.

There lived in early seas somewhat singular creatures known as sea scorpions. They possessed a coat or armor and had jointed bodies supplied with legs for crawling, swimming and seizing their prey. They belonged to the crustaceans and were lobster-like in form, though unlike, in some particulars, any creature now living. In the division of animals they would be classed with articulates as crabs, lobsters, centipedes, spiders and insects. The bodies of these sea scorpions were divided into rings or joints, each fitting nicely into each other and forming a complete armor. The celebrated Hugh Miller was the first to discover them in certain parts of the old red sandstone, which through his subsequent explorations yielded so many hidden secrets. The workmen called the remains "seraphims," because of the many markings on the hard coat of its jointed armor, which suggested to their untutored minds the idea of feathers and wings. Their resemblance to land scorpions was so close that but from the fact that they breathed water instead of air they would be removed out of the crustacean class. Their tails were powerful and the head or front part of the body was covered with a carapace which, with their size, reaching nearly six feet in length, made them dangerous prey in early times. They had compound eyes made up of small lenses which enabled them to see distinctly. These curious animals were what is known as "jawfooted," and used their limbs for walking, seizing their prey and for eating. They are believed to have been rapacious in their habits, and possibly acted as scavengers in the early seas. They were numerous in the Silurian seas, but entirely disappeared in the Carboniferous age.

EARLY SEA ROVERS.

In the Lower Silurian age a remarkable cephalopod made its appearance in great numbers and variety, but entirely disappeared in the Jurassic period. We refer to the Orthoceratite, which derives its name from a Greek word signifying straight horn. The animal lived in a straight or conical shell, divided into a great many chambers through which ran a siphuncle or tube. Some of these attained a length of between thirty and forty feet. The animal was something like a squid, and had long muscular arms with which it seized and overcame its prey.

The siphuncle or tube traversing the septa of the shell doubtless enabled the animal to inflate the chambers of its ponderous house with air, by which means it could easily rise to the surface of the water, the expulsion of which enabled it to rapidly sink to the bottom again. They were probably the sea rovers of the early seas and occupied the place of fishes. Their unwieldy shells, however, must have impeded their progress, except when traveling in a straight line. Hundreds of species are found, some not larger than a lead pencil. Owing to the hard shell in which the animal was incased their forms are preserved, and in a petrified state some of the larger weigh hundreds of pounds. Could the reader stand one of these on end it would reach to the eaves of an ordinary three-story house.

THE GREAT FISH LIZARDS.

Formidable as the sea scorpions which we have described may seem to have been, they were as infants compared with the fish lizards that inhabited the ancient seas. One of them, the Ichthyosaurus, was probably the most rapacious and formidable of all the aquatic monsters. In some respects they resembled whales, yet were not related to them. The Icthyosaurus had two pairs of paddles or fins, but its long tail was its chief organ of propulsion. The fore paddles were composed largely of small bones, forming a sort of bony pavement, and along the backs of some species was a row of bony excrescences. It was doubtless without scales, and covered with a leathery skin. It had no distinct neck, but possessed powerful jaws, which were a marked feature of the monster. Its enormous mouth was filled with more than two hundred teeth inserted in a long groove. Some attained a length of nearly forty feet, and with jaws from four to six feet in length, one can imagine something of its formidable character. A peculiar feature was the eyes, which were exceedingly large, measuring, in some instances, nearly or quite two feet in diameter, and were surrounded by a series of overlapping bony plates. The expanded pupil doubtless admitted much light and gave the reptile great power of vision. The bony plates performed an important office, for not only did they protect the monster's eyes when diving into deep water, but they probably acted the part of a microscope or a telescope at the will of the creature. "By bringing the plates a little nearer and causing them to press gently upon the eyeballs, so as to make the eye more convex, or bulging out, a nearer object could be discerned. And on relaxing the pressure, thus enlarging the aperture of the pupil and diminishing the convexity, a distant object could be focused upon the retina." The Ichthyosaurus fed principally on fishes, as the coprolites or petrified excrement plainly shows. It is evident that they were viviparous or produced their young in a living state, as in whales. It is believed that they were to a certain extent amphibious, and sometimes sought the shores. The bony structure of the fore paddles indicates this, also the fact that a strong inverted bony arch beneath the chest passed from shoulder to shoulder, which would support the monster when on the land. The Ichthyosaurus, which was planned on a different line from any creature, probably, that has ever existed, flourished in the Jurassic period, disappearing in the succeeding age.

THE GREAT SEA LIZARDS.

Contemporary with the fish lizards were the long-necked sea lizards, which in structure were, if possible, more curious than the former. The Plesiosaurus combined certain characteristics, more or less marked, of several animals, but at the same time it stood out distinct and was related to none. It had the head of a lizard, the teeth of a crocodile, the neck of a swan, the ribs of a chameleon, the paddles of a whale, and the trunk and tail of an ordinary quadruped. It was more distinctly reptilian than the Ichthyosaurus. The teeth were set in distinct sockets as they are in crocodiles. Each pair of ribs are said to have surrounded the body with a complete girdle formed of five pieces, as in the chameleon and iguana, giving it facility for contracting and dilating the lungs. Probably the most remarkable feature of the structure was its neck. It was composed of a greater number of vertebræ than the swan's, which, compared with the remainder of its body, has the longest neck of the feathered race. So of the Plesiosaurus among reptiles or quadrupeds. The unusually long neck would necessarily support a comparatively small head. Its paddles were also unusually long, and must have given it means of rapid propulsion. Owing to its small head and long neck it was probably unable to cope with the fish lizards, hence was compelled to live in lagoons and near the shore. It was also probably able to live on the land a portion of the time, though out of its native element it would present an awkward appearance. The remains of more than twenty species of sea lizards have been found, some of which indicate a monster of forty feet in length. Unlike the fish lizards, the Plesiosaurus had flat or slightly concave vertebræ, which made the backbone less flexible than those of the cup-shaped Icthyosaurus. They appear suddenly in the New Red Sandstone, and disappear as suddenly in the Cretaceous period. It was a marine, air-breathing carnivorous reptile, and was furnished with an apparatus which enabled it to sink to the bottom and rise again at pleasure. As far as known, it was the creation and development of a type that had not previously existed, and that has no successor.

THE OLD TIME DRAGONS.

After becoming conversant with the forms of the monsters that lived in the early ages of the world, one is not surprised that traditions of hideous dragons have come down to us from the misty past. For several hundred miles along the flanks of the Rocky Mountains lie inhumed the remains of dragon-like forms that prove reality to be sometimes stranger than fiction. We refer to a large family of reptiles known as Dinosaurs. They lived in Mesozoic times, and are found in Europe, Africa, India, Australia, as well as in this country. According to the Vailian theory, the earth at that time was surrounded with rings of aqueous vapor, which overcanopied the globe, producing a uniform or hothouse temperature, which was exceedingly favorable to the development of reptiles. We doubt not that their remains will yet be found in arctic and antarctic lands, among other semi-tropical plants and animals. This was pre-eminently the age of reptiles. In this era they culminated and began their decline.

Dinosaurs were the largest terrestrial and semi-aquatic reptiles yet discovered. Some resembled crocodiles in many respects, and others the bony structure of the ostrich, especially in the pelvis or bony arch connecting the hind legs. Some species being three-toed and walking on their hind legs left tracks which early geologists mistook for huge bird tracks. The body of some species was covered with a horny coat of armor consisting of bony plates and spines. They had four legs, the hinder being very large. Some attained a size rivaling the modern rhinoceros and elephant.

One species of this reptile, known as Brontosaurus, was a vegetable-feeding lizard, about sixty feet long, and must have weighed at least twenty tons. Its small brain and spinal cord indicates a slow-moving reptile. It was amphibious in its habits, and probably fed on aquatic plants and land vegetation. Its tracks cover the space of a square yard. The body was comparatively short, with massive hind legs, and a powerful neck and tail. While the vertebræ were large, yet those of the neck and body had large cavities, connecting with other internal cavities, giving them the appearance of being honeycombed. They combined both strength and lightness, which was necessary in the support of the long neck. But the vertebræ of the enormous tail, which dragged on the ground, was more solid, giving proper balance and equipoise to the other parts.

The thigh bone of a species known as Atlantosaurus, found by Prof. Marsh in the Rocky Mountains, is over six feet long. The reptile attained the enormous length of over eighty feet. It seems to have walked on its hind feet, and must have stood fully thirty feet high. Its legs and ponderous tail formed a tripod when the creature was at rest. The feet were armed with claws, which, if in proportion to its other parts, must have been formidable weapons of defense. The remains upon which it fed have been found with the monster and show that it lived at a time when the Rocky Mountain region was covered with a subtropical vegetation. This is another proof of the Vailian theory or annular system existing in the early ages of the world.

Another large species of Dinosaurs found in the Rocky Mountain region is known as Aptosaurus, a complete skeleton of which was obtained by Prof. Marsh. It was about thirty feet long. Morosaurus, another form, was very numerous. It had a small head and long neck. The vertebræ of the neck were lightened by deep cavities in the centre, as those of birds of flight. This species was about forty feet long and walked on all fours. Dinlodacus was another which attained a length of about fifty feet. It had slender jaws, and its teeth were confined to the fore part of the same. Several species of Dinosaurs were found in England prior to their discovery in America. One, Cetiosaurus, attained a length of probably thirty-five feet or more, and was doubtless endowed with great physical strength. In this chapter we have briefly noted some of the herbivorous or vegetable-eating dragons of olden time; in our next we will speak of the carnivorous or flesh-eating dragons, some of which possessed even more strange and weird forms than those we have described.

CARNIVOROUS AND OTHER DRAGONS.

As previously said, during the Mesozoic era, Dinosaurs and other reptiles spread over a large portion, if not the whole earth. The overcanopying vapors produced an Eden-like climate, causing tropical vegetation to flourish from pole to pole. During that period, existing probably for millions of years, there appeared a variety of forms and types of Dinosaurs, as well as other reptiles. In the last chapter we had something to say of the great herbivorous lizards that walked on the land and swam in the seas and lagoons of olden time; but in this chapter we will speak of some of the carnivorous species that appeared at the same time. While many species were smaller than those we have described, yet they were more active. One of them, named Megalosaurus, attained a length of thirty or more feet and walked on its hind feet. It had formidable teeth set in sockets and enormous claws, and was doubtless an active and aggressive creature, somewhat similar in nature to lions and tigers of our day. Some parts of the skeleton show an approach to the ostrich in type. The teeth were long and turned backward in the shape of a pruning knife, and had serrated edges. They produced the combined effect of a knife and a saw cutting with the whole of their concave edges. The larger bones were hollow, combining lightness and strength and enabling the reptile to move with agility. In hopping or leaping it is not unreasonable to believe it had the power to bound at least its own length, which would be from twenty to more than thirty feet. It must have been able to raise its head to a height of fifteen or twenty feet.

Another carnivorous Dinosaur, and very remarkable in some respects, was discovered by Prof. Marsh, and to which he gave the name Ceratosaurus or horned Dinosaur. This great lizard showed certain characteristics not found in others previously discovered. The skull supported a horn, and all of the bones of the pelvis were fused together as in modern birds. The vertebræ also differed from the other Dinosaurs, and it differed externally. Its body was protected as that of crocodiles, with long, bony plates in the skin, especially along the top of the head and neck and along the back. Its head seen from above resembled the crocodile. The teeth of this horned dragon resembled those of the Megalosaur described above. The eyes were protected by protuberances of the skull. The fore limbs were comparatively small, but armed with powerful claws.

The remains of another wonderful Dinosaur discovered on the eastern flank of the Rocky Mountains by Prof. Marsh is known as Stegosaurus or plated lizard. Its bones indicate aquatic life, but it doubtless passed much of its time on the land. It was covered, in some parts at least, with large bony plates and with spines. Some of these sharp spines were more than two feet long and stood in pairs along the tail. Along its back from near the head to the tail there stood up huge, bony plates from two to three feet in diameter. Standing on all fours, the head and tail were near the ground, the body forming an arch from twelve to fifteen feet high. It had a rather small head with large eyes and a single row of teeth which were replaced by others when lost. The fore limbs were short and massive, and pointed with five fingers. The hind legs were much more powerful, and when desirable the reptile could support itself on them and its tail, forming a tripod. The three toes on the hind feet were covered with bony hoofs. The fore limbs could move in any direction like the human arm, and were doubtless used in self-defense. But its most effective weapon was its tail, armed with four pairs of long spines or horns. The most remarkable feature of this strange animal is yet to be noted. It possessed two sets of brains. One was located in the skull and the other in the region of the haunches, formed by the enlargement of the spinal cord, and was ten times larger than the former. This curiously formed lizard attained a length of thirty or forty feet.

Another of the Dinosaurs is known as Iguanodon. It was an enormous reptile, attaining, according to Prof. Owen's estimate, a length of fifty or sixty feet. It was one of the largest of the saurians of the ancient world. Nothwithstanding the fact that it had a body larger than the elephant, yet it probably habitually walked on its hind legs. Think of a creature stalking on the land on its hind feet dragging after it a tail twenty or thirty feet long, and with its head sufficiently elevated to gaze into the upper windows of an ordinary four-story house! A large pointed bone grew out from each hand or fore foot forming a kind of huge spur, and was probably used in self-defense, and also in pulling down the foliage of trees upon which it fed. The Iguanodon, of which there were many species, doubtless spent much of its time in the water, using its huge tail as a means of propulsion.

But the most singular of all Dinosaurs is yet to be described. It is called Triceratops. It derives its name from the Greek *treis*, three; *ceras*, horn; *ops*, face. It was one of the last of the Dinosaurs and flourished near the close of the Mesozoic or Reptilian age. It would seem as though nature had exhausted her ingenuity in its curious formation. It had a ponderous head supporting two large horns above each eye and another one over the nose. Its head was seven or eight feet long. The back part of the skull arose into a kind of a huge crest, and was protected by a fringe of heavy plates. The teeth were remarkable in having two distinct roots, and the mouth formed a kind of beak sheathed in horn similar to turtles. This great lizard was covered in part or in whole with bony plates and spines. The fore feet were larger than in most Dinosaurs and it evidently walked on all fours. It was about twenty-five feet long and had the smallest brain in proportion to the skull of all known vertebrates. Prof. Marsh says that the head of this strange creature must have increased in size generation after generation in order to bear its armor of bony plates which was finally the cause of its extinction. In the course of evolution its head became too heavy for its body, and it literally died of "big head." The remains of this reptile are found in what is known as the Laramie beds, which are of fresh water or brackish water origin, extending some 800 miles along the eastern flank of the Rocky Mountains. With these are found the fossil remains of other Dinosaurs, Plesiosaurs, crocodiles, turtles, and other reptiles, birds, fishes, and mammals.

The remains of many other species of Dinosaurs have been found of which our limited space will not permit us to speak, but for a description of which we

must refer the reader to the works of Marsh, Hutchinson and others. Our next chapter will be devoted to flying dragons.

(*To be continued.*)

SOME RARE BIRDS.

WE publish to-day an engraving—for which we are indebted to our honored contemporary, the *Illustrirte Zeitung*—of some of the rare birds that were exhibited in Berlin last year by the Ornis, an ornithological society. Very high prices were set on some of these little birds. The pair of little green, flat-tailed parrots were valued at $240, because they are so rare, even in their native country (Australia), that live specimens of them have never before been seen in Europe, and stuffed specimens are seldom found in the natural history museums. The green, flat-tailed parrot was represented among many other ornithological curiosities in Hagenbeck's collection at the Chicago Exposition. For the amateur collector the small-beaked parrot with fiery red under-wings, from South America, is especially attractive because it is so tame and droll. Another bird that never before reached Europe alive was the South American yellow-hooded oriole. Other specimens which were very pleasing on account of their beauty, although not quite so rare, were the little humming bird, the organist of Brazil, the Indian dove, the two finches, one from America and the other from Africa, and the dwarf owl from Mexico, and finally the little European bird known as the Alpine wall climber.

EXHIBIT OF RARE BIRDS.

1. Mocking bird. 2. Song thrush. 3. Thrush. 4. Alpine wall climber. 5. Magellan's finch. 6. Finch. 7. Mexican dwarf screech owl. 8. Oriole. 9. Organist bird. 10. Humming bird. 11. Spring fruit dove. 12, 13, 14. Parrots.

THE DURFORT ELEPHANT.

MR. ALBERT GAUDRY has written a memoir upon the Durfort elephant for the volume published by the professors of the museum on the occasion of the centenary of this establishment. It is somewhat curious that the most imposing specimen of the rich paleontological collection under Mr. Gaudry's care, although very well known to the scientific world and to the public at large, had never before been the subject of a special work. Our readers know from the articles of the lamented Dr. Fisher how the skeleton of the gigantic proboscidian was discovered, and with what skill it was extracted from its repository, and they are not ignorant of the fact that science is indebted to Mr. Cazalis de Fondouer for this beautiful piece.

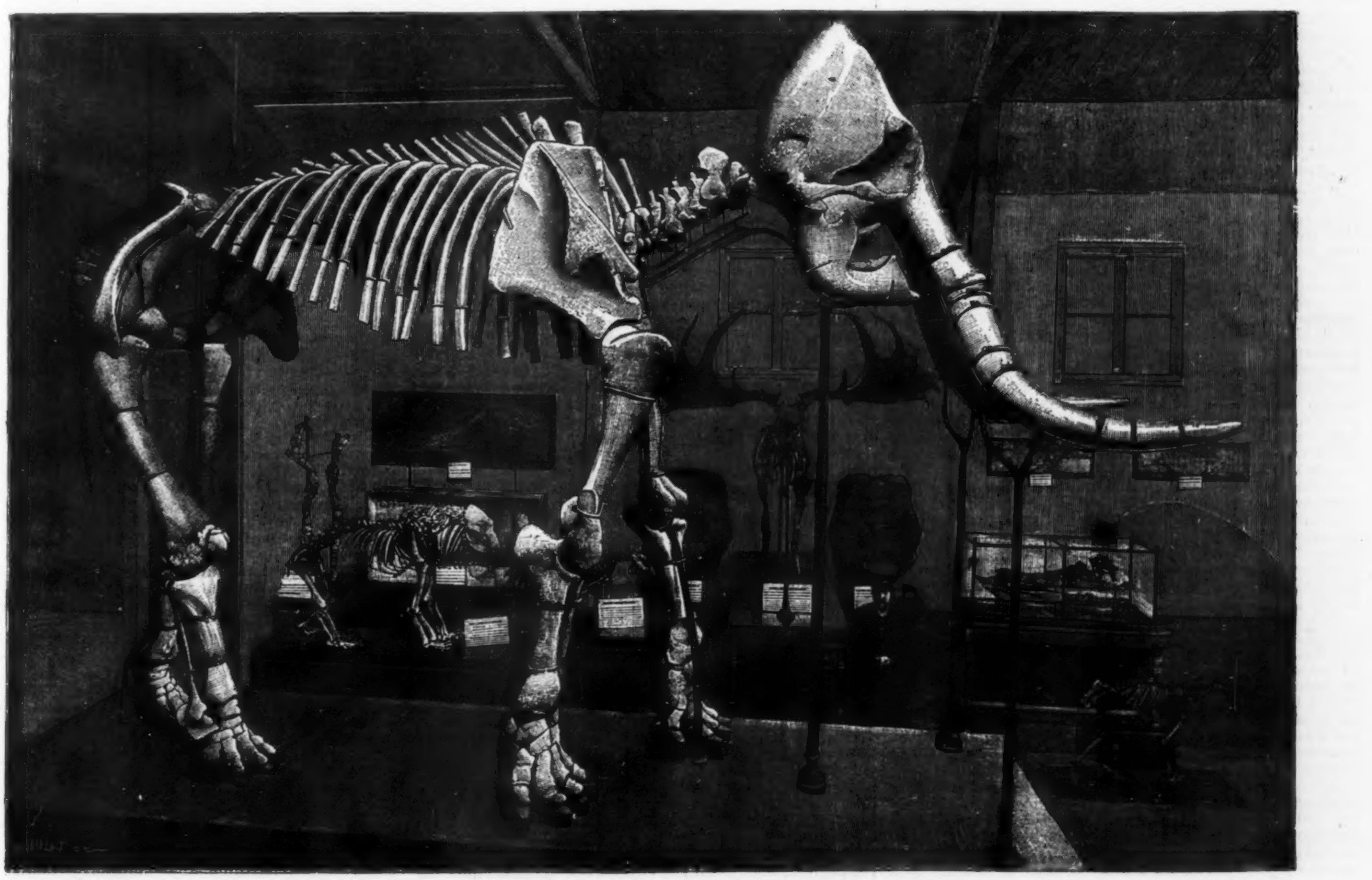
Mr. Gaudry, in his memoir, discusses the name that it is proper to give the Durfort elephant. He shows how delicate a matter the specific determination of fossil elephants is, on account of the numerous transitions that connect all the forms. The Durfort animal, which is from the Pliocene, must be referred to the *Elephas meridionalis*, not to the primitive type of this species, but to a breed already modified that begins to approach the quaternary elephants.

Along with the skeleton of the elephant there has been found at Durfort a large number of bones belonging to various genera of animals—hippopotamuses, bisons, deer, a rhinoceros and a horse. All these animals must have perished in the mud of a small marsh of the Pliocene epoch, since the majority of the bones have been found with their anatomical connections.

There have also been found in the same deposit a batrachian of the size of a large common toad, some remains of a pike and various shells of mollusks. A study of vegetable impressions made by Messrs. Saporta and Marion permits of restoring the landscape in which the Durfort elephant moved. Forests of various oaks, among which *Quercus Lusitanica* was pre-eminent, extended around the Durfort pond. There were also some beeches and some arborescent species that have representatives at present on the Caucasus or in Persia, such as *Planera Ungeri* and a *Parrotia*.

Mr. Gaudry terminates his memoir with some interesting remarks upon the dimensions of terrestrial animals during geologic times and with some philosophical considerations upon the disappearance of these giants of past epochs. According to the eminent professor, the reign of brute force took place during secondary times, while the dinosaurians, which were the most gigantic of all the continental quadrupeds, and doubtless the most stupid, were living. The real apogee of the animal world, comprising the handsomest, most active and most intelligent quadrupeds, shows itself at the end of Tertiary time, during the Miocene and Pliocene epochs, that is to say, immediately before the reign of man.

Mr. Gaudry's memoir is accompanied with a superb phototype from which the accompanying engraving was made.—*La Nature.*



SKELETON OF THE GREAT FOSSIL ELEPHANT OF DURFORT, AT THE PARIS MUSEUM OF NATURAL HISTORY.

AN INTERNATIONAL LANGUAGE.

AT a recent meeting of the New York Academy of Science, Dr. Achilles Rose read the paper. The desirability of having a single international language must have impressed itself upon the minds of all who had attended an international medical congress. Very few of the members at such meetings were able to speak, or even to understand, more than two languages, perhaps only their own, whereas three had been official, and at the next meeting five would be recognized. The advantages to be derived from a single official language had occupied the minds of many thinkers. The best known of later attempts to invent a language was that of Volapuk, but the impracticability of this as a language of science had been conceded by those who had given the matter special attention. The rivalry of nations was against the acceptance of any of the three great living languages—German, French and English—as official, not to mention other objections, particularly their want of richness in combinations. On the other hand, Greek was free from these objections and possessed many positive advantages. True, it was called a dead language, but it was dead only in the minds of college professors. It was spoken to-day by several million people essentially as it was in the times when the classics were composed. Medical terminology and that of the arts and sciences in general were already dominated by the Greek language. It was particularly rich in combinations and was the most beautiful language spoken, its innate superiority accounting for its survival of centuries when the Greeks themselves had suffered all kinds of reverses and been reduced to a handful in numbers. The author estimated the number of those speaking the Greek language to-day at seven millions. Latin, on the other hand, was not a living spoken language, and was kept in existence only through philological and theological literature.

The conversational language of a nation was the key to its written language, and the easiest and best way, the most efficient way, was to begin with the language as the people were accustomed to use it in everyday life. According to the present methods of teaching Greek, it would be considered too difficult to learn, and could never become an international language. But this would be true of any language whatever if it were taught as Greek and Latin were taught in our colleges. There was no truth in the statement that the Greek of to-day was dominated by the Slavonic or Turkish; nearly everything of foreign origin had been excluded. Specimens of magazines and letter-writing in Greek were exhibited.

The author criticised severely the collegiate method of teaching Greek, which he said originated in 1528, with Erasmus, a crank in this matter. How difficult it would be to gain a knowledge of English by pursuing the same course, starting, for instance, with the poems of Longfellow, parsing every sentence and pronouncing the words as it might suit the fancy of the teacher! To learn a language one should begin with easy books, children's books, and listen to the conversation of natives. By such a method one would soon be enabled to do away with the dictionary, which at present even scholars required in reading Greek.

A language which gave terms to all new inventions and discoveries, and which could not be replaced by any other, was already, to a certain extent, an international language.

Dr. W. H. Thomson thought the question naturally assumed two forms: 1. Was an international language at all practicable at a medical congress? 2. If it was, what language should be selected? Regarding the first question he saw no possibility of establishing an international language for medicine or science unless a revolution were effected in our systems of education and there was co-operation among the different educators of the world in bringing about so desirable an end. The law of the evolution of language made it imperative, if such a result was to be accomplished, that the language be learned in such a way that men could think in it.

Afferent and Efferent Language.—Physiologically considered, all language was afferent and efferent. Afferent language came through the eye and ear; efferent language passed out through the organs of speech or in the handwriting. Afferent language was acquired chiefly through the ear, and it was only later in life that we used the eye in reading and writing. Yet the colleges would have us learn Latin and Greek exclusively through the eye, which had the least developed tract connecting it with the centers for expression. Dr. Thomson could speak very feelingly upon this subject, for he had studied Greek under his preceptors diligently for many years, and had translated a number of the classics, yet he had never found it possible to think in that language.

He was then set to studying Arabic in the same manner—*i. e.*, by the eye alone—but he soon became convinced that he could never get a practical use of it in that manner, and abandoned the method, and went to live among the Arabs themselves, with the result that, notwithstanding the difficulties besetting that copious language, he could yet, after the lapse of twenty-five years, express himself in it with facility. The same difficulties encountered by himself in the study of Greek and Latin were being encountered to-day by his sons at Harvard, where they continued, as in other colleges, to teach those languages by sight instead of by sound and conversation. German and French were taught at Harvard in the same manner; a fact which had always made him sorry for young men who had to acquire their knowledge of the languages at that institution.

Supposing it possible to introduce an international language for medicine, he agreed with Dr. Rose that Greek was best. He would unhesitatingly choose Greek, because of its unparalleled and marvelous structure for expressing ideas, and notably its power to express ideas related to science in the most accurate, the most concise and clearest manner yet devised by man. In this regard it was as perfect as English was deficient in power to express relation between things. Greek showed matchless value.

Dr. S. S. Burt acknowledged that Greek was a beautiful and desirable language, but his judgment told him that English was destined to be the dominant language, for the reason that the English people were becoming the dominant race. He did not believe any language would be agreed upon except it were that of the people who were in the ascendency, in whose speech affairs of government were transacted, and science, art and literature were recorded.

The president, Dr. Roosa, spoke very feelingly upon the collegiate way of teaching languages. He had devoted a great deal of time to Latin and Greek, and, like the other gentlemen who had spoken, felt that what he knew to-day was very little indeed. He started to study German in the same manner, and after some time found himself in Bremen unable even to make known his wishes as to a hotel. There he entered a German family where not a word of English was spoken, had no English acquaintances, and the result was that in two months' time he could go about all Germany and make his wants known without difficulty.

If we were to have an international language it could only be, as Dr. Thomson had said, by a revolution of teaching methods, and Dr. Roosa despaired of such a revolution, because the hide-bound notions of college professors were simply beyond any ordinary assault; for a man from New York to talk to men from Cambridge or New Haven as to ways of teaching would be very much as if he should go to the tomb of the prophet with his boots on.

[FROM LIPPINCOTT'S MAGAZINE.]

HOW I GAINED AN INCOME.

To support and educate a family is not an easy task. So much every one will admit. Men, fully equipped for such an end, having had it held before them from early boyhood, find it difficult of accomplishment, and often, if complications of ill health or misfortune arise, impossible. Perhaps, therefore, a woman who has accomplished so much may have a claim, even if a very modest one, to success, and may the less hesitate to urge the claim if in doing so she is forced to admit failure in other respects. I will begin, therefore, by confession that I certainly have not, so far, attained the goal of my early ambitions. I have no name well known in the world of letters, and am not in a position to boast of my literary attainment. I have simply succeeded in educating my children, thoroughly equipping them for an independence which was mine only after much suffering and effort, and in securing a comfortable income for myself and the prospect of an independent old age. Yet I venture to hope that possibly my experience may have a greater value for discouraged women than if it had lain among the laurels of literature.

My intention, when I entered the field as a bread winner some ten years ago, was distinctly to be a literary light, possibly even a star of magnitude. Indeed, in the earlier days of returned manuscripts I considered journalism as entirely beneath my consideration, and when, through force of circumstances, I reluctantly entered upon the thorny path familiar to all writers for the press, I did so with the flattering belief that as an art critic I had little in common with journalists as such, and still less with reporters, whom I then held in light esteem.

Alas for my egotistical conceit! I soon had reason to learn that I was but a minnow in the ocean of journalism. A very short experience of the outskirts of the world of letters taught me two things very thoroughly, one being that to gain any hearing at all it was necessary to possess more than mere ability; the other, that sympathy for me as a woman with three children to support might help me over the threshold, but certainly would not secure me an income.

But, after all, these are important lessons, and I may at least claim for myself that I learned them quickly, whereas in many cases they are either not learned at all or are acquired too late for the knowledge to be of practical advantage. Yet even after I had realized them as facts it took me several years to put them into practice: I might never have done so but for the plain speaking of a business friend. One day, in deep discouragement, I was bemoaning the difficulties I met with—the unpleasantly frequent occurrence of rejected manuscripts, for example—and mournfully declaring that, although I had put all my ambitions aside, and become not only a journalist and reporter, but a perfect hack, doing all sorts of odds and ends of miserably worthless work, writing up openings, and scampering round New York and Brooklyn like an overdriven steed for a mere pittance, I could barely meet my necessary expenses and could by no possibility give my children the advantages I desired. He fell upon me somewhat in this wise:

"I am not surprised at it. I never expect to see you doing anything but struggling. There's no money in *your* line. But of course you look down upon us business people, who could buy up all the poor authors in New York City and not miss the money. I could soon show you how to make money. How do you suppose I make mine? But you would never do it, and would probably think it beneath you."

It had not, indeed, occurred to me to ask where my friend's wealth came from. I knew that his family lived comfortably and that he was considered a person of means, and my interest in the matter remained languid even after his explanation was made. It conveyed but little intelligence to my mind when he went on to state that he had been the advertising manager for a large firm, and added, with a certain complacent confidence, that much of its success was owing to his efforts.

Advertising, indeed, only suggested to me columns of enormous type, inartistic cuts, and general vulgarity. The mere thought of such a method of gaining an income was revolting to me, when at last it dimly dawned upon my mind that there might be something in such a plane of effort worthy of consideration. But sometimes changes in our destiny are brought about by very simple agencies; and I owe it entirely to that shot of my friend's, fired apparently into the air, that to-day I am in comfortable circumstances, possessed of more or less property, that my children are fully equipped for their own place in life (which is by no means a low one), and that old age, as it slowly advances, possesses no terrors for me—if indeed I should at forty-eight, in these days of rejuvenescence, dare to consider myself even middle aged. But hard work and much anxiety do not keep one youthful, and my contemporaries must forgive me if I confess that my main object now is to continue to prosper in my undertakings in such a way as to secure an independence to the end.

This record being in some sort a confession, I feel that it is incumbent upon my honesty to admit that more than mere pride was broken down before I seriously turned my attention to the field of money getting suggested to me in which I have since succeeded. Grief entered my life, and ambition died before it—personal ambition, I mean—while the desire for my children's welfare remained as strong as ever. It no longer seemed a matter of any importance to win that name in the world of letters which had so long appealed to my love of fame. I turned from the grave of my son to the fortune of my daughters: money alone could secure for them the fuller, higher education with which I desired to equip them. The first step in its accumulation was taken when I ordered an unobtrusive little card to be printed for circulation among business houses, stating that, as an experienced writer, I was willing to prepare advertisements, letter heads, and circulars.

This modest card I inclosed in personal letters, addressed to the heads of firms which I selected from the business directory. I can but smile as I recall the absolute ignorance which I displayed in the whole matter, and yet, possibly, it was the unconventional method of my address which won me a hearing. Be that as it may, the very first batch of such letters sent through the mail brought me two replies requesting me to call. One was from a large clothing house, the other from a manufacturer of wall paper. Perhaps I never in my life received a more complete setback than when, in each case, after being introduced into the sanctum of the head of the firm, I was asked what I had to propose as advantageous for their line of business. I, in my utter ignorance and incapacity, had expected all proposals to come from them; and there I sat dumfounded, face to face with my own emptyheadedness. However, my woman's wit came to my aid. I said, "I must first know the nature of the business before I can offer suggestions." I can laugh now as I recall how often this lucky hit saved me from appearing the fool I really felt; for it always enabled me to add that, as much of what I heard was new to me, I should like to consider it, and call again when I should have a proposal to make. Some of my proposals must have been amusing. What consultations I had with my business acquaintances after such interviews! What absurd suggestions I often made, and how difficult I should have found it to carry many of them out had they been accepted, my readers may imagine. But, although I made endless mistakes and met many serious rebuffs, I soon realized the truth of my friend's assertion that money could be made in the business world. Whereas every editor of whom I had any experience had been personally sympathetic and yet sorry to see me and glad to get rid of me, every business man I have ever approached has looked upon me as a possibly profitable vehicle, has never dreamed of offering me sympathy, but has been able and willing to pay liberally for any work I undertook and thoroughly accomplished.

At that time trade journals were not as common as they have since become, and one of my earliest successes in the advertising world was the publication of a small magazine for a firm of very good standing, "rushing in," like the proverbial fool, where in the acquired wisdom of experience I should now hesitate to enter. I undertook the whole business—editing, illustrating (looking up artists for this purpose), printing, publishing, and circulating. To be candid, I had not the smallest idea of the responsibility I had undertaken. No book of value ever launched upon the ocean of literature has been born with greater pangs than this twopenny halfpenny little advertising magazine. What pride I had in it! What immense trouble I took! What agonies I endured when printers and artists conspired, as it appeared to me, to thwart my intentions! It was my first effort in the field of pure money making *versus* fame seeking. Well, it was, in its small way, a success. The first issue was followed by many succeeding numbers, and although it came out only quarterly, it served a most useful purpose in my new scheme of life. I carried a copy of it everywhere, and it answered as a passport more thoroughly than any mere introduction could have done. Could I not proudly assert that I had written every article in it myself, printed and published it, without any trouble to the merchant? It led to many more such orders, and ultimately to regular salaried engagements.

How funny my work was sometimes! I remember, early in this experience, undertaking to write a pamphlet upon the effect of electricity upon the circulation of the blood, for which I was to be paid only if, upon its being read to a committee, it proved perfectly satisfactory. The ordeal of reading before the committee, which consisted of six organizers of a company, was severe; but I had asked a good price for it, and came out triumphant. I don't think there was much accuracy of knowledge among the judges of my performance. Nor shall I ever forget the first terrible efforts in my new field of work when they took the form of canvassing from store to store to obtain orders for pamphlets or descriptive articles. Well indeed do I remember starting out each bright morning, determined to call upon at least thirty stores and interview as many of the managers as I could induce to see me. Ah, well, the rebuffs I gained were hard to bear; many a day I returned in tears: and yet they were few in comparison to the rejected manuscripts of the past. In a shorter time than seems credible, within one year from the start, I was being offered salaries of forty and fifty dollars a week to attend to the advertising details of good firms.

What an education it has been! One such position I occupied, and from the experience gained there was able, upon leaving it, to double and treble the good salary I received. If fame remained as far off as ever, there was abundant compensation in a full purse, in a home slowly growing up, in children's lives made happy and their future assured. Soon there was money to invest, and enough insight had been gained in the business world to make such investments profitable. In time managing other people's businesses developed into carrying one on independently, and experience still confirms the wisdom of my friend's advice.

When, in these later years, scarcely a day passes over my head without an appeal from some struggling woman for help or advice, it has seemed to me that a frank record of my own experience as a bread winner would be helpful to them; they may more readily forgive my constant assertion that ignorance and incompetency are the true lions in the road to success when I own how incompetent I have been myself. A valued friend of mine, a lady doctor widely known throughout New England, gave me one of the most valuable lessons of my life by calmly remarking, after I had been deploring one of my many failures, "Well, my dear, you overrated yourself, you see." That is just it. We are all so apt to overrate ourselves, and there is nothing like a business experience for knocking the conceit out of one. Women more particularly, who, being refined and fairly well educated, are thrown upon their own resources, and who in their own circles have been accustomed to a sort of success, who can write bright letters, or do a little painting or decorative needlework, enter the bread winner's field imagining that they must succeed because their friends consider them exceptionally clever. There never was a greater mistake. The business world pays only for what it wants, and if women—and men too, for that matter—would take this truth home to them and ponder upon it, much heartbreaking disappointment would be spared them and their friends. For this is what the market value of a thing really means; it will fetch only what it is worth.

I recall with shame how earnestly and how vainly a well wisher of mine, an eminent publisher, tried many years ago to impress this fact upon my mind. "You will succeed," he used to say, "as soon as you produce what somebody wants, but not so long as your merit is only that of a woman who is struggling." In common with a great many other women not brought up to work, I had a vague sort of idea that my misfortunes were a passport and would gain me an income. Let me assure every woman similarly placed that they never will. Sympathy is readily awakened, but it is in the nature of things shortlived. Respect for effort earnest and continued is a much better ally. In an experience ranging over many years, I must honestly say that every time I have failed it has been through my own ignorance and incompetency, and that my success has been built up upon failures many and severe. The best equipment that either men or women could have is definite knowledge, if it be only of one thing. The first question I ask those who come to me for advice is, "What can you do?" If the answer is—as it almost invariably proves to be—"Anything," my heart fills with despair for the applicant. In the money making world, "anything" means "nothing;" it is overrun with a vast army of incapables ready to rush in and undertake "anything." What is needed is some one who can do something, as opposed to any one who can do anything. Competency is the only equipment that is worth anything nowadays.

In the world of letters a fleeting success may be gained by a brilliant writer, but not a tangible, money-making success unless there is some knowledge behind the brilliancy. In the world of business, incomes are results, not of brilliant incompetency, but of accuracy, method, devotion, steady application, often of attention to things of so little apparent value that the educated but inexperienced woman entering the world of work considers them as of little importance, while upon them may hinge the success of a large business. It is a trite thing to speak of "character" as an important factor in success, but it is pre-eminently so in the business world; and many a woman has failed simply because she has not learned the value of punctuality or looked upon it in the light of "character." Yet honor in the business world is built up upon it. The punctual discharge of obligations is the key note of business reputation; to be "as good as one's word" is equivalent to capital.

How trivial such statements seem! But life is made up of little things, and I have seen many brilliant careers cut short by neglect of them, as I have also watched, in the passing years, the gradual acquirement of property by women who had nothing to commend them to their employers but steadiness and punctuality. Woman to-day should reflect that they can enter any field of work they choose. No one forbids them; all they have to do is to prove their competency when they *have* entered it, and the reward will be theirs. It sounds unsentimental, but it expresses a very sincere conviction when I add that I do not believe that any thoroughly competent person need long seek work in vain in New York City, and this is not in any special direction, but in all. There is always room at the top, and indeed plenty to spare a long way before the top is reached. While it is true that mechanical inventions tend more and more to the demand for specialized knowledge of certain branches of manufacture and trade, and thus sometimes compel a corresponding degree of ignorance of other branches, it is not less true that the qualities which command actual success are the same always and everywhere: they are punctuality, earnestness, devotion to detail. Such qualities cover a multitude of the shortcomings of ignorance; and, whatever may be true of the wonderful "coming age," in the present conditions of the business world no one need starve who possesses them and is imbued at the same time with a willingness to learn.

In my later experience as an employer of labor, these home truths are daily impressed upon my mind. How difficult it is to secure good and faithful service, how rare to find intelligence wedded to punctuality and regard for trifles! I am sure I only echo the thoughts of hundreds of employers when I ask, "Where, in the vast army of the unemployed, of which we hear so much, is the man or woman who will fill the positions I have to offer?" Echo answers and always will answer, "Where?" until more persons learn to lay aside vague yearnings for imaginary honors and accept faithfully the limitations and responsibilities of every-day business life. Its rewards may not be so tempting as the glittering bubble of fame, but they are a good deal more substantial, and what is more to the point, more likely to be reached.—*A Bread Winner.*

LIGHT.

POINCARE ON MAXWELL AND HERTZ.*

AT the time when Fresnel's experiments compelled all researchers to admit that light is due to the vibrations of a very subtile fluid filling the interplanetary spaces. the researches of Ampere made known the mutual actions of currents, and founded electrodynamics.

But one step more was required to suppose that this same fluid, the ether, which is the cause of luminous phenomena, is at the same time the vehicle of electrical actions. This step Ampere's imagination enabled him to take; but the illustrious physicist, while announcing this seductive hypothesis, did not see that it was so soon to take a more precise form, and receive the beginning of its confirmation.

It was still, however, but a dream without consistence, till the day when electric measures indicated an unexpected fact—a fact recalled by M. Cornu in the last *Annuaire*, at the end of his brilliant article devoted to the definition of electric units. To pass from the system of electrostatic units to the system of electrodynamic units, a certain transformation factor is employed, the definition of which I will not recall, as it is to be found in M. Cornu's article. This factor, which is also called the ratio of unities, is precisely equal to the velocity of light.

The observations soon became so precise that it was impossible to attribute this concordance to chance. One could not doubt, therefore, that there were certain

* Translation of an article by M. Poincare, in the *Annuaire* of the Bureau des Longitudes for 1894.—*Nature.*

intimate relations between the optic and the electric phenomena. But the nature of these relations would perhaps still have escaped us if Maxwell's genius had not guessed it.

CURRENTS.

Every one knows that bodies can be divided into two classes: conductors where we prove the transference of electricity, that is to say, of voltaic currents, and insulators or dielectrics. To the old electricians dielectrics were purely inert, and their part consisted in opposing the passage of electricity. If this were so, we could replace any insulating body by another of a different kind without changing the phenomena. Faraday's experiments have shown that it is nothing of the kind.

Two condensers of the same shape and dimensions put in communication with the same sources of electricity will not take the same charge (even if the thickness of the isolating wire be the same), if the nature of the isolating matter differs. Maxwell had made too deep a study of Faraday's works not to understand the importance of dielectric bodies and the necessity of restoring to them their proper function.

Besides, if it be true that light is but an electric phenomenon, it follows that when it is propagated through an insulating body, this body is the place of the phenomenon, therefore there must be electric phenomena localized in dielectrics; but of what nature are they? Maxwell answers daringly: They are currents.

All the experiments up to this time seemed to contradict this; currents had never been observed except in conductors. How could Maxwell reconcile his audacious hypothesis with such a well-founded fact? Why do the hypothetical currents under certain circumstances produce manifest effects which under ordinary conditions remain absolutely unobservable?

It is because dielectrics oppose to the passage of electricity, not a greater resistance than the conductors, but a resistance of a different kind. A comparison will make Maxwell's thought clearer.

If we endeavor to bend a spring, a resistance is encountered which increases in proportion as the spring is bent. If, therefore, we have at our disposal only a limited force, a moment will come when the resistance being unsurmountable, the movement will stop and equilibrium be established; at last, when the force ceases to act the spring will bound back, giving back all the work expended to bend it.

Suppose, on the contrary, that we wish to move a body immersed in water. Here again we meet with resistance which will depend on the velocity, but which, if this velocity remains constant, will not increase in proportion as the body advances; the movement will therefore continue as long as the force acts, and equilibrium will never be attained; finally, when the force ceases to act, the body will not tend to return, and the energy used for making it advance cannot be restored; it will have been entirely transformed into heat by the viscosity of the water.

The contrast is manifest, and it is necessary to distinguish between *elastic* and *viscous* resistance. Then dielectrics would behave, for electric movements, like elastic solids in the case of material movements, while conductors would behave like viscous liquids. Hence two categories of currents; current of displacement or Maxwell's currents which traverse dielectrics and the ordinary conducting currents which circulate in conductors.

The first, having to overcome a sort of elastic resistance, can be but of short duration; for, this resistance increasing continually, equilibrium will be rapidly established.

The currents of conduction, on the contrary, having to overcome a sort of viscous resistance, can consequently last as long as the electromotive force which causes them. Let us look again at the convenient comparison which M. Cornu has borrowed from hydraulics. Suppose we have water under pressure in a reservoir; let us put this reservoir in communication with a vertical tube; the water will rise in it, but the movement will stop so soon as the hydrostatic equilibrium is reached. If the tube is large, there will not be any friction, or loss of charge, and water thus raised could be used for producing work. We have here a picture of displacing currents.

If, on the contrary, the water of the reservoir flows out by a horizontal tube, the movement will continue so long as the reservoir is not empty; but if the tube is narrow, there will be a considerable loss of work and a production of heat by friction. We have here a picture of conducting currents.

Although it is impossible and of little use to try to represent to ourselves all the details of this mechanism, one may say that all happens as if the displacement currents had a number of little springs to bend. When the currents stop electrostatic equilibrium is established, and the springs are so much the more bent as the electric field is more intense. The work accumulated in these springs, that is to say, the electrostatic energy, can be wholly restored so soon as they can unbend themselves. It is thus that mechanical work is obtained when the conductors are allowed to obey the electrostatic attractions. These attractions would thus be due to the pressure exercised on the conductors by the bent springs. Finally, to follow the comparison to the end, the disruptive discharge must be likened to the rupture of overstrained springs.

On the other hand, the work employed for producing conduction currents is lost and wholly transformed into heat like that expended in overcoming the friction or the viscosity of fluids. It is for this reason that the conducting wires get hot. From Maxwell's point of view there are only closed currents. For the old electricians this was not so; they looked upon a current as closed which circulates in a wire joining the two poles of a battery. But if, instead of reuniting the two poles directly, one puts them in communication respectively with the two armatures of a condenser, the instantaneous current, which lasts until the condenser is filled, was considered open; it went, it was thought, from one armature to the other across the wire of communication and the battery, and stopped at the surface of the two armatures. On the other hand, Maxwell supposed that the current traverses the insulating plate, which separates the two armatures, under the form of a displacement current, and that it is thus completely closed. The elastic resistance which it meets on the passage explains its short duration.

Currents can manifest themselves in three ways: by their calorific effects, by their action on magnets and currents, by the induced currents to which they give rise. We have already seen why conduction currents develop heat, and why displacement currents do not do so. On the other hand, however, according to Maxwell's hypothesis, the currents which he imagines must, like the ordinary currents, produce electromagnetic, electrodynamic and inductive effects.

Why have we hitherto been unable to put these effects in evidence? It is because a displacement current, however feeble, cannot last long in the same direction; for the tension of our springs, ever increasing, would soon stop it. There cannot, therefore, be in dielectrics either continuous currents of long duration or sensible alternating currents of long period. The effects will, however, become observable if the alternation is very rapid.

THE NATURE OF LIGHT.

According to Maxwell, this is the origin of light. A luminous ray is a series of alternating currents produced in dielectrics, or even in the air or the interplanetary vacuum, which changes its direction a thousand billion times every second. The enormous induction due to these frequent alternations produces other currents in the neighboring parts of the dielectric, and it is thus that the luminous waves spread from point to point. Calculation shows us that the rate of spreading is equal to the ratio of the units, that is to say, to the velocity of light.

These alternating currents are a kind of electrical vibrations; but are these vibrations longitudinal like those of sound or transversal like those of Fresnel's "ether"? In the case of sound the air undergoes condensation and rarefaction, alternatively. On the contrary, Fresnel's ether, when vibrating, behaves as if it were formed of incompressible layers, capable only of sliding one over the other. If there were open currents, the electricity going from one extremity to the other of one of these currents would accumulate at one of the extremities; it would condense or rarefy itself like air; its vibrations would be longitudinal. But Maxwell admits only closed currents; this accumulation is impossible, and electricity behaves like Fresnel's incompressible ether; its vibrations are transversal.

EXPERIMENTAL VERIFICATION.

So we find again all the results of the undulatory theory. But this was, however, not enough to induce the physicists, who were more charmed than convinced, to accept Maxwell's ideas. All that could be said in their favor was that they did not contradict any of the observed facts, and that it was a great pity if they were not true. But experimental confirmation was wanting; it had to be waited for during twenty-five years.

A divergence had to be found between the old theory and Maxwell's, which was not too delicate for our rough means of investigation. There was only one which afforded an *experimentum crucis*.

The old electro-dynamics required electro-magnetic induction to be produced instantaneously; but, according to the new doctrine, it must, on the contrary, be propagated with the velocity of light.

The question was, therefore, to measure, or, at least, to ascertain, the rate of propagation of inductive effects. This has been done by the illustrious German physicist, Hertz, by the method of interferences.

This method is well known in its applications to optical phenomena. Two luminous rays issuing from the same source interfere when they meet at the same point after having followed different paths. If the difference of these paths is equal to the length of a wave—that is to say, to the path traversed during one period, or a whole number of wave lengths—one of the vibrations is later than another by a whole number of periods: the two vibrations are therefore at the same phase, they are in the same direction, and they re-enforce each other.

If, on the contrary, the difference of path of the two rays is equal to an odd number of half wave lengths, the two vibrations are in contrary directions, and they neutralize one another.

The luminous waves are not the only ones susceptible to interference; all periodic and alternating phenomena propagated with a finite velocity will produce analogous effects. It happens with sound. It ought to happen with electrodynamic induction, if the velocity of propagation is finite; but if, on the contrary, the propagation be instantaneous, there will not be any interference.

But one cannot put these interferences to the proof if the wave length is greater than our laboratories, or greater than the space that the induction can traverse without becoming too feeble. Currents of very short period are absolutely essential.

ELECTRIC EXCITERS.

Let us first see how they may be obtained with the help of an apparatus which is a veritable electric pendulum. Suppose two conductors united by a wire; if they are not of the same potential, the electric equilibrium is broken in the same way as the mechanical equilibrium is deranged when a pendulum is swung from the vertical. In the one case as in the other, the equilibrium tends to re-establish itself.

A current circulates in the wire and tends to equalize the potential of the two conductors in the same way as a pendulum seeks the vertical. But the pendulum will not stop in its position of equilibrium; having acquired a certain velocity, it passes this position because of its inertia. Similarly, when our conductors are discharged, the electric equilibrium, momentarily re-established, will not maintain itself and will be destroyed by a cause analogous to inertia; this cause is *self-induction*. We know that when a current stops it gives rise in the adjacent wires to an induced current in the same direction. The same effect even is produced in the wire in which the induction current circulates, which finds itself, so to speak, continued by the induced current.

In other words, a current will persist after the disappearance of the cause which produced it, as a moving body does not stop when the force which had put it in motion ceases to act.

When the two potentials shall have become equal, the current will therefore continue in the same direction, and will make the two conductors take opposite charges to those which they had to start with.

In this case, as in that of the pendulum, the place of equilibrium is passed; in order to re-establish it, a backward movement is necessary.

When the equilibrium is regained, the same cause immediately destroys it, and the oscillations continue without ceasing.

Calculation shows that the duration depends on the capacity of the conductors; it suffices, therefore, to diminish sufficiently this capacity, which is easy, to have an electric pendulum susceptible of producing alternating currents of extreme rapidity.

All this was well established by Lord Kelvin's theories and by Feddersen's experiments on the oscillating discharge of the Leyden jar. It is, therefore, not this which constitutes the original idea of Hertz.

But it is not sufficient to construct a pendulum; it must also be put into movement. For this, it is necessary for some agent to move it from its position of equilibrium, and then to stop abruptly—I mean to say, in a time very short in relation to the duration of a period; otherwise the pendulum will not oscillate.

If, for example, we move a pendulum from its vertical position with the hand, and then, instead of loosing it suddenly, we let the arm relax slowly without unclasping the fingers, the pendulum, still supported, will arrive at its place of equilibrium without velocity, and will not pass it.

We see then that with periods of a hundred-millionth of a second, no system of mechanical unclamping could work, however rapid it might appear to us with regard to our usual units of time. This is the way in which Hertz has solved the problem.

Taking again our electric pendulum, let us make in the wire, which joins the two conductors, a cut of some millimeters. This cut divides our apparatus into two symmetric halves, which we will put in communication with the two poles of a Ruhmkorff coil. The induced current will charge our two conductors, and the difference of their potential will increase with a relative slowness.

At first the cut will stop the conductors from discharging themselves. The air plays the part of an insulator, and keeps our pendulum away from its position of equilibrium.

But when the difference of potential becomes large enough, the jar spark will pass, and will make a way for the electricity accumulated on the conductors. The cut will all at once cease to act as an insulator, and by a sort of electric unclamping, our pendulum will be freed from the cause which prevented it returning to its equilibrium. If the complex conditions, well studied by Hertz, are fulfilled, this unclamping is sudden enough to enable oscillations to be produced.

The apparatus, called an "exciter," produces currents which change their direction from 100,000,000 to 1,000,000,000 times per second. Because of this extreme frequency they can produce inductive effects at a great distance. In order to render these effects simple, another electric pendulum, called a "resonator," is employed. In this new pendulum, the cut and the coil, which only serve for the unclamping, are suppressed; the two conductors reduce themselves to two very small spheres, and the wire is bent back in a circle in a way to approach the spheres to each other.

The induction due to the exciter will put this resonator in vibration the more easily as the periods of the two are less different. At certain phases of the vibration, the difference of potential of the two spheres will be large enough to produce sparks.

PRODUCTION OF INTERFERENCES.

We have thus an instrument which shows the effects of an inductive wave emitted from the exciter. We can study what happens in two ways: either expose the resonator to the direct induction of the exciter at a great distance, or else make this induction work at a short distance on a long conducting wire, along which the electric wave will go, and which will work in its turn by induction at a short distance on the resonator.

Whether the wave propagates itself along a wire or across the air, one can produce interferences by reflection. In the first case, it will reflect itself at the extremity of the wire, which it will follow again in an inverse direction; in the second, it will reflect itself on a metallic leaf which acts as a mirror. In the two cases the reflected wave will interfere with the direct wave, and we can find places where the spark of the resonator will cease to pass.

The experiments made with the long wire are easier; they furnish us with very precious instruction, but they will not serve as *experimenta crucis*; for in the old as well as the modern theory, the quickness of an electric wave along a wire must be equal to that of light. The experiments on the direct induction at a great distance are, on the contrary, decisive. They show that not only the quickness of propagation of induction across the air is finite, but that it is equal to the quickness of the wave propagated along a wire, complying with the ideas of Maxwell.

SYNTHESIS OF LIGHT.

I shall insist less on other experiments of Hertz, more brilliant, but less instructive. Concentrating with a parabolic mirror the wave of induction taken from the exciter, the German savant obtains a veritable cluster of electric rays, capable of reflecting and refracting themselves regularly. The rays, if the period, already so small, were a million times shorter still, would not differ from the luminous rays. We know that the sun gives out several kinds of radiation, some luminous because they act on the retina, others obscure ultra-violet or infra-red, which manifest themselves by their chemical or calorific effects. The first only owe their qualities, which make them appear to us of a different nature, to a kind of physiological chance. To the physicist the infra-red does not differ more from the red than the red from the green; the length of a wave is only greater; those of the Hertzian radiations are much greater still, but there are only differences of degree, and one may say, if Maxwell's theories are true, that the illustrious Professor of Bonn has realized a veritable synthesis of light.

CONCLUSIONS.

But our admiration for so much unhoped for success

must not make us forget the progress which still remains to be accomplished. Let us therefore try to exactly summarize the results which are definitely attained.

First, the velocity of direct induction across the air is finite, without which the interferences would be impossible. The old electro-dynamics are therefore condemned. What must one put in its place? Is it Maxwell's theory (or at least something approaching it, for one would not expect the divination of the English savant to have foreseen the truth in all its details)? Although the probabilities accumulate, the complete demonstration is not yet reached.

We can measure the length of a wave of Hertzian oscillations; this length is the product of the period by the velocity of propagation. We should, therefore, know this velocity if we knew the period; but this last is so small that we cannot measure it; we can only calculate it by a formula due to Lord Kelvin. This calculation leads to numbers which agree with Maxwell's theory; but the last doubts will only be done away with when the velocity of propagation has been directly measured.

This is not all: things are far from being so simple as one might think, from the above short account. Diverse circumstances come to complicate them.

First, there is round the exciter a radiation of induction; the energy of this apparatus radiates, therefore, externally, and as no fresh source comes to supply it, it soon disperses, and the oscillations die out very rapidly. It is here that one must look for the explanation of the phenomenon of multiple resonance, which was discovered by MM. Sarasin and De la Rive, and which at first appeared irreconcilable with the theory.

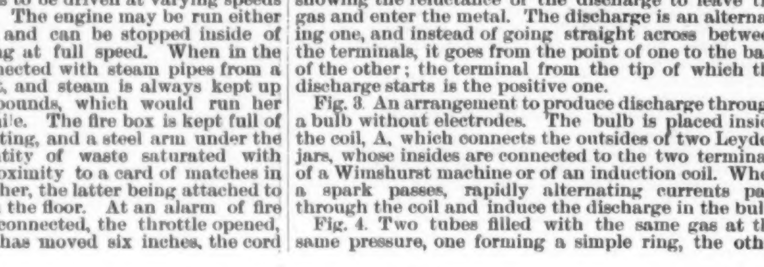
On the other hand, we know that light does not precisely follow the laws of geometrical optics, and the difference which produces diffraction is more considerable as the length of the wave is greater. With the great length of the Hertzian undulations these phenomena must assume an enormous importance and trouble everything. No doubt it is fortunate, for the moment at least, that our means of observation are so coarse, otherwise the simplicity which seduced us at the first sight would give place to a labyrinth where we should be lost. It is from this probably that different anomalies arise, which have hitherto not been explained. It is also for this reason that the experiments on the refraction of rays of electric force have, as I said above, but little demonstrative worth.

There still remains a difficulty which is more serious, but which is, no doubt, not insurmountable. According to Maxwell, the coefficient of electrostatic induction of a transparent body ought to be equal to the square of its index of refraction. This is not so. The bodies which follow Maxwell's law are exceptions. We are evidently in the presence of phenomena much more complex than we thought at first; but one has not been able to explain anything, and the experiments themselves are contradictory.

There still remains, therefore, much to be done. The identity of light and electricity is from to-day something more than a seducing hypothesis: it is a probable truth, but it is not as yet a proved truth.

THE LARGEST FIRE ENGINE.

THE city of Hartford, Connecticut, is proud in possessing the largest and most powerful locomotive steam fire engine in the world. Over 10 ft. high and 17 ft. long, it weighs 8½ tons, and can throw 1,350 gallons of water per minute. The boiler contains 301 copper tubes. This engine, at her first trial, threw, through 50 ft. of hose 3½ in. in diameter, a horizontal stream of water a distance of 348 ft., and threw two streams, each as large as that thrown by an ordinary fire engine, a distance of over 300 ft. The road driving power of the engine is applied through two endless chains running over sprocket wheels on each of the main rear wheels, permitting these wheels to be driven at varying speeds when turning corners. The engine may be run either forward or backward, and can be stopped inside of fifty feet when running at full speed. When in the house the boiler is connected with steam pipes from a heater in the basement, and steam is always kept up to about ninety-five pounds, which would run her about a quarter of a mile. The fire box is kept full of material ready for lighting, and a steel arm under the engine carries a quantity of waste saturated with kerosene oil in close proximity to a card of matches in a holder under a scratcher, the latter being attached to a cord tied to a ring in the floor. At an alarm of fire the steam pipes are disconnected, the throttle opened, and, before the engine has moved six inches, the cord pulls the scratcher, and the rod carrying the blazing waste swings around under the fire box, igniting the shavings and wood. Cannel coal is burned, and steam enough can be generated in two minutes to run the engine at a speed of thirty-one miles an hour.—*The Graphic.*



"JUMBO," THE LARGEST STEAM FIRE ENGINE IN THE WORLD.

ELECTRIC DISCHARGE THROUGH GASES.

PROF. J. J. THOMSON, F.R.S., lectured at the Royal Institution lately on the "Electric Discharge through Gases," demonstrated by a considerable number of experiments, including those described below, and illustrated by the accompanying cuts, which we take from the *Engineer.*

Fig. 1 represents a tube with a thin piece of platinum leaf stretching across the middle and provided with a branch passage which communicates with a barometer tube. When the side tube is open the discharge, instead of crossing the platinum portion, goes the longer way round by the side tube. When the cistern of the barometer tube is raised so as to close the side tube by a pellet of mercury, the discharge is forced back through the main tube.

FIG. 1

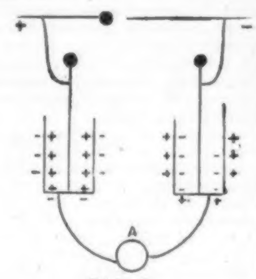


FIG. 3

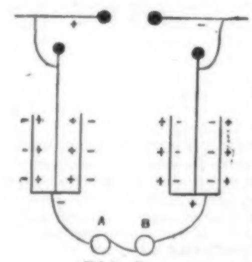


FIG. 5

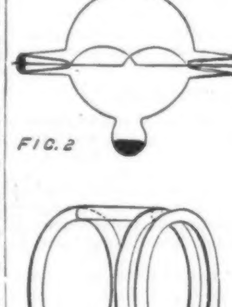


FIG. 2

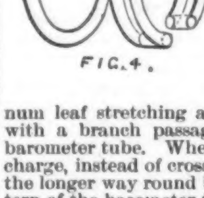


FIG. 4.

FIG. 6

Fig. 2 represents the arrangement for an experiment showing the reluctance of the discharge to leave the gas and enter the metal. The discharge is an alternating one, and instead of going straight across between the terminals, it goes from the point of one to the base of the other; the terminal from the tip of which the discharge starts is the positive one.

Fig. 3. An arrangement to produce discharge through a bulb without electrodes. The bulb is placed inside the coil, A, which connects the outsides of two Leyden jars, whose insides are connected to the two terminals of a Wimshurst machine or of an induction coil. When a spark passes, rapidly alternating currents pass through the coil and induce the discharge in the bulb.

Fig. 4. Two tubes filled with the same gas at the same pressure, one forming a simple ring, the other bent back upon itself. When this arrangement is placed inside the coil the discharge passes through the simple ring, but not through the other. In the first case the total electromotive force round the ring is finite, in the second it vanishes.

Fig. 5. Apparatus for testing the conductivity of various substances by means of these electrodeless dischargers. A standard bulb is placed in A, and the conductivity of the substance is tested by seeing the effect it produces when placed in B upon the brilliancy of the bulb in A. By this method it was shown that the molecular conductivity of a rarefied gas conveying a discharge was greater than that of the best conducting metal.

Fig. 6. Arrangement to show that at excessively low pressure the discharge cannot pass through a rarefied gas. The inner bulb contains gas at a pressure at which a discharge passes. The outer bulb is a mercury vacuum. When the apparatus is cold no discharge passes through the outer bulb, but one goes through the inner. When the apparatus is warmed, so that the pressure of the mercury vapor is higher, the discharge goes through the outer, but not the inner. The outer bulb being now a conductor, shields the inner from the effects of the alternating currents in the coil.

Fig. 7. An experiment to show that the discharge is stopped when it has to go across the lines of magnetic force, and facilitated when it goes along them. When the magnet is "off" the discharge passes through the inner bulb, but not through the outer square tube. When the magnet is "on" the discharge goes through the outer tube, but not through the inner.

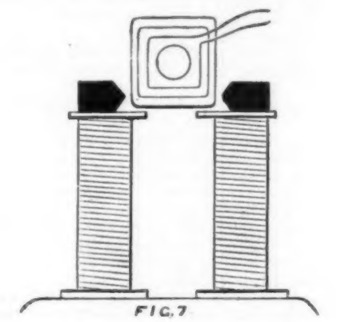


FIG. 7

FOREIGN METALS IN COPPER.

THE following is the method adopted by the author: Twenty-five grammes of the sample are dissolved in a mixture of 200 c. c. of water, 100 c. c. of pure concentrated sulphuric acid, and 45 to 46 c. c. of nitric acid of sp. gr. 1·21. The quantity of the last named reagent is reckoned so as to afford a small excess over that necessary for the oxidation of the quantity of copper taken, while the amount of sulphuric acid represents a considerable surplus, in order to prevent the separation of basic salts of bismuth and antimony when the solution is subsequently diluted. When the whole of the copper is dissolved, the solution is diluted with 200 c. c. of water to prevent the formation of crystals of copper sulphate. The resulting liquid is generally clear, but it may be turbid from the separation of insoluble antimoniates of copper and bismuth, which must in that case be filtered off and examined separately. The original solution, or the clear filtrate, as the case may be, is warmed to 40° C., and treated with sulphur dioxide in a rapid stream to decompose the remainder of the nitric acid, the reduction being complete in about half an hour, provided the temperature specified, which is the most favorable for the reaction, be observed. The solution, which should smell of sulphur dioxide, may be turbid from the presence of metallic silver precipitated by the reducing agent. Should it be desired to determine the silver in the wet way, the precipitation of traces not reduced by the sulphur dioxide is effected by the addition of a few drops of hydrochloric acid and the mixed precipitate of silver and silver chloride filtered off, converted completely into chloride and weighed in the usual manner. If, on the other hand, a dry assay for silver is to be made, the turbidity due to the separation of metallic silver may be disregarded, and the main body of liquid, together with the trace of metallic silver, is transfixed to a two-liter flask and precipitated with pure potassium thiocyanate, a rapid stream of sulphur dioxide being meanwhile maintained. A slight deficiency of potassium thiocyanate is used, so that a small fraction of the copper may remain in solution. The solution of potassium thiocyanate is of such strength that about 500 c. c. are required to precipitate 25 grammes of copper. The total bulk is then made up to two liters, the precipitate allowed to subside and a known volume of the supernatant liquor filtered off; 1,800 c. c. is a convenient amount to take. The excess of sulphur dioxide is driven off by evaporation, and the foreign metals originally present in the copper, such as antimony, arsenic, bismuth, tin, iron and nickel, are separated and determined by the customary analytical methods. In making the calculations of the analysis it is necessary to correct for the volume of the cuprous thiocyanate in order to ascertain with what fraction of the 25 grammes of copper originally taken the quantity of liquid drawn off after precipitation corresponds. This involves a knowledge of the specific gravity of cuprous thiocyanate. The author has determined this value, and finds it to be 2·999, so that the volume occupied by the cuprous thiocyanate from 25 grammes of copper is 15·98 c. c. The total bulk of liquid in the two-liter flask may therefore be taken as 1,984 c. c., and the relation between this number and that of the liquid drawn off, viz., 1,800 c. c., determines upon what fraction of the 25 grammes of copper the estimation of foreign metals has been effected. Test analyses of pure copper, to the solution of which known quantities of impurities had been added, prove the accuracy of the method.—*W. Hampe, Chem. Zeit.*, 1893, *xvii.*, 1691-92; *The Analyst.*

AN extraordinary incident is reported from Trealaw, South Wales. A truck of cattle, sheep, and pigs was being discharged at the station, when it was discovered that the pigs had devoured three sheep, the skins and bones only remaining. The pigs' mouths were covered with blood.

MANUFACTURE OF OAKUM.

OAKUM is manufactured from the old hemp rigging taken from American and English vessels. American rigging is considered the best on account of its not being so heavily coated with tar as the English rigging, which, with the use of lukewarm water, makes it less difficult to separate fiber.

The old rope is first cut up into 8 to 10 ft. lengths, and then fed into a cutting machine. This machine contains two steel knives, about 18 in. in length. The upper, or movable, has a stop at one end of the blade, which prevents the rope when being cut from slipping. The attendant passes the end of the rope along the top of the bottom blade to the stop of the upper blade, which, in descending, cuts the rope off into 6 in. lengths. From the cutting machine they are taken to a soaking or softening tub, where they are steamed from 5 to 15 minutes. This softens the rope so that the strands can be separated by hand. After steaming they are then taken to the washing machine. This machine is oval-shaped, and made mostly of oak. It is about 15 ft. in length, 10 ft. in width, and about 4 ft. in height. On one side, across the center of the machine, is a shaft connected to which are 8 oak paddles, 3 ft. long and 1½ ft. in width. These paddles revolve inside of a 4 ft. channel containing the rope to be washed. Attached to a similar shaft on the other side of the machine, across the center, are three slightly curved iron arms which, when revolving in the channel, throw out the material after washing. The channel of machine is first nearly filled with lukewarm water, then about six two-bushel baskets of soaked rope are added. The paddles are then set in motion, driving and tearing apart the pieces of rope for about fifteen to twenty minutes. If the material is too dark on account of the tar, about one quart of turmeric is added to give it a golden color. After the washing is completed the shaft, containing the 2½ ft. arms, is set in motion, the revolving of which causes the arms to lift and throw out the material, emptying the machine in about five minutes. After draining, it is carted out to a drying platform, where it is spread out by hand and left to dry about six hours. After drying it is taken to the picking machines. The machine is fed by an attendant, who runs the material between two small steel rollers. From the rollers it is taken up and passed between small and large tooth-lined cylinders, which tear the fibers apart, taking out the grit. The cylinders are about 5 ft. in length, the large one being 4 ft. in diameter. The teeth are similar in shape to those of a saw. They are made in strips and screwed fast to the frame of cylinder. Each strip contains 3 teeth, 1½ in. in length. These strips are placed about 1 in. apart, in rows of 28 sets of teeth across the length of cylinder. There are 22 rows of the sets, making in all about 1,844 teeth. From the picking machines it goes to the finishing apparatus. This machine consists of a main cylinder, 4 ft. in diameter, with curved pointed teeth about 1½ in. long and about 1 in. apart. There are also 4 workers, the cylinders of which are 18 in. in diameter, containing curved teeth similar in shape to those on the main cylinder; 3 fans, 18 in. in diameter, containing brushes 1 in. long, in rows 6 in. apart; 2 strippers, 6 in. in diameter, and 1 doffer, 2 ft. in diameter. The machine is fed in the manner as the pickers. The material passing between the rollers and taken up by a worker, then stripped and brushed or fanned, then passed between another worker and main cylinder to be stripped and brushed again, and so on until every particle of dirt is separated from the fiber. After passing between the doffer, a large cylinder, it falls down through a shaft below, where it is taken up and weighed and pressed into 50 lb. bales. Twenty-five hands can turn out about 100 bales per day, with 1 cutter, 2 washers, 2 pickers, and 3 finishers. The sketches were taken from the plant of B. Mills' Sons, Jersey City.

[Continued from SUPPLEMENT, No. 959, page 15325.]

THE MANUFACTURE OF STRAW CELLULOSE.*

By JAMES BEVERIDGE.

III.—YIELD, ETC.

IT has always been the aim of manufacturers to obtain the highest yield of cellulose from unit weight of straw, and to this end various modifications of the soda process have been suggested and worked on a manufacturing scale. A process with this intent was brought out some years ago by Leunig and worked by an English company, but the results were very indifferent. Caustic soda was used to remove the incrusting organic and mineral matters surrounding the fibers substantially in the manner above described, but instead of bleaching with hypochlorites, chlorine gas was employed. This, as is generally known, is a costly and anything but an easy process to carry on economically and free from nuisance, if not actual danger, and it is not surprising that the Leunig process proved unsatisfactory from a commercial point of view.

From what I have previously stated it might be inferred that a sulphite process for the treatment of straw would prove of value, inasmuch as by it the maximum yield of pulp would be obtained for the reasons already given—namely, that cellulose is less soluble in solutions of bisulphites of lime, soda, or magnesia than those of caustic soda. Notwithstanding that this is substantially true, there are yet serious defects attached to the quality of the product which render it practically worthless for use in the manufacture of papers of a high quality.

This arises from the fact that the silica in the straw remains untouched by the bisulphite solutions, and appears in the cellulose in a very objectionable form. When such cellulose is converted into paper, the silica appears upon the surface of the sheet as small shining scales. It is also obvious that there is only one available method of cheaply removing this silica, which consists in dissolving it out with a weak solution of caustic soda. My experiments in this direction have proved that this can be done, and that the cellulose produced by this dual treatment is of first-class quality. The yield, however, remained substantially the same as that obtained by digesting the straw in caustic soda alone. In this, as in the Leunig process, all organic substances readily soluble in weak caustic solutions are removed.

Some very interesting figures on the question of yield which I here reproduce were given in the *Papier Zeitung* some few years ago by Roth. I understand them to be the results obtained in actual manufacture, and as such are very instructive to the pulp and paper maker. They clearly show that the yield from unit weight of straw varies inversely with the quantity of caustic soda used for digesting, and that the amount of bleaching powder required to bleach the pulp varies directly with the yield. Assuming the temperature (or pressure), the time used for digestion, and the quality of the straw with respect to its percentage of cellulose to be kept practically constant, I have found by a long series of experimental trials that the above conclusions are strictly correct.

These manufacturing yields as given by Roth seem to indicate that it is possible to obtain 50 per cent. of bleached cellulose from straw, but whether the product corresponded in quality to what is found in the market as straw pulp seems to be very doubtful. The fact that 7 cwt. of bleaching powder were required to bleach one ton of it plainly indicates that it was of low quality. It is, of course, possible to treat straw with weak caustic solutions, to obtain a high yield, but this product cannot be looked upon as "straw pulp" of ordinary quality.

In practice, the actual yield seldom exceeds 40 per cent. In one pulp mill with which I have been connected, working a mixture of oat and wheat straw, with occasionally a small parcel of rye and barley, all grown in Holland, the yield of bleached cellulose containing 10 per cent. of moisture fluctuated over a long period between 40 per cent. and 41 per cent.

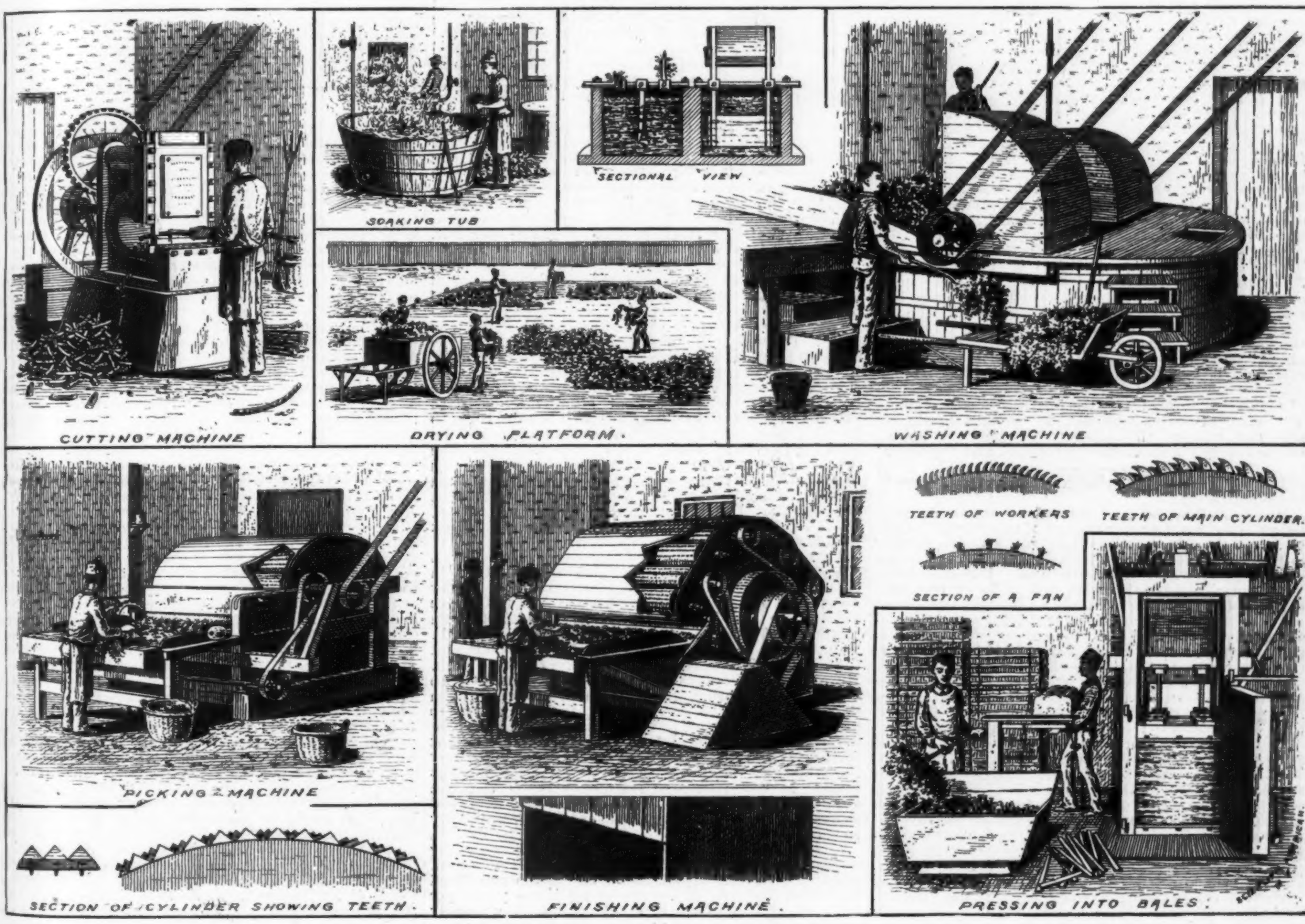
The bleaching powder required to bleach this airdry pulp varied from 18 to 20 per cent. These results closely correspond to those given by Roth in the Austrian factory.

Lately the so-called "sulphate process" has been applied in a German factory, and as the digesting fluid consists largely of sulphide of sodium, which, as might be inferred from its properties, has a less solvent action on the cellulose than caustic, it is very probable that the yield obtained in this process exceeds that of the caustic process pure and simple. I am, however, unable to state definitely whether this is so or not, or what the yield actually is.

Passing now from the question of yield, I come to another of great importance, namely, the influence of the quantity of silica in straws on the loss of soda, and a consideration of the methods for mitigating this loss. It is almost unnecessary for me to remind you that the composition and quantity of the ash found in straws varies very greatly. The most complete analyses of the ashes of straws which I have been able to find are those published by Wolff (Ashen Analysen). The following table embraces his average results.

While the straw is being boiled substantially the whole of the silica passes into solution as silicate of soda. The alkali thus combined is practically lost to the pulp maker, because it is rendered inactive for the process of digestion. The quantity of alkali thus ren-

* From the *Journal of the Society of Chemical Industry.*



MANUFACTURE OF OAKUM.

COMPOSITION OF THE ASHES OF STRAWS.—WOLFF'S "ASHEN ANALYSEN."

—	Total Mineral Matter in Straw.	Percentage Composition of the Ash.								
		K_2O	Na_2O	CaO	MgO	Fe_2O_3	P_2O_5	SO_3	SiO_2	Cl
Barley straw, average of 4 analyses	8·10	25·46	1·92	7·53	2·62	2·19	3·94	3·91	51·43	3·75
Oat " " " 8 "	7·77	38·37	3·99	4·25	2·53	1·79	2·66	3·06	35·68	7·99
Rye " " " 3 "	4·32	26·28	0·74	11·10	4·45	3·19	8·97	5·57	36·86	3·63
Wheat straw, one analysis	3·25	12·16	1·00	6·82	4·00	1·02	3·29	5·76	65·34	0·60

dered useless will vary, of course, with the amount of silica contained in that quantity of straw which will produce one ton of air-dry bleached cellulose on the quantity of potash rendered soluble, and also on the chemical constitution of the silicate. There being an excess of caustic soda always present, I have assumed the silicate to be a normal one, having the formula Na_2SiO_3.

Assuming this to be correct, I have calculated, as shown in Table II., first, the quantity of straw required to produce one ton of air-dry cellulose; second, the amount of silica contained in this quantity of straw; and then, finally, the quantity of soda, reckoned as 60 per cent. alkali (Na_2O), which would combine with this silica. Going a step further, by way of example, and assuming 21 lb. of 60 per cent. caustic to be the amount required to digest 1 cwt. of the Dutch wheat straw (Ijpolden) above given, the total alkali (60 per cent.) used to produce one ton of cellulose is 10·29 cwt., and of this 4·39 cwt., or 42 per cent., would be neutralized by this silica.*

It is this loss which increases the cost of soda so enormously in straw cellulose works. Unless the silicate of soda in the waste lyes or the recovered ash can be decomposed in some practical or economical way, or the recovered ash sold as such, the present highly efficient systems of soda recovery by multiple evaporation, by which 80 per cent. of the soda can be easily recovered, are of little value to the straw pulp maker. Indeed, in most cases where the silica approaches in quantity anything like that shown in the table, the recovered ash is of little value for further use in digesting. For reasons formerly stated, it is manifest that the most economical course to follow is to select those straws only for the manufacture which by chemical test are shown to contain the least quantity of silica.

There are several methods, alike in principle, of reconverting this silicate of soda into available caustic alkali. The most simple way consists in adding bicarbonate of soda to the solution of the recovered ash, whereby the silicate is decomposed, normal carbonate of soda being formed with the separation of free silica. The same decomposition can be brought about by pumping gaseous carbonic acid through the liquor, but as this gas is not always available, and the cost of pumping is a serious item, and that the silica thus separated is in a very gelatinous state, this system is not practicable.

Messrs. Sutherland and Kynaston, who took out a patent some years ago for the use of bicarbonate, claim to obtain the silica as a heavy or granular precipitate, in which state it can be separated from the carbonate of soda liquor with comparative ease. The separation of the silica is one of the great difficulties of this process. The use of bicarbonate serves the additional purpose of replacing the alkali which is invariably mechanically lost, but if the quantity of silica and the percentage amount of soda recovered are both great, it can be shown by a simple calculation that the amount of bicarbonate required to effect the decomposition abnormally increases the volume of the alkali liquors in circulation; that is to say, more bicarbonate is used than corresponds to the soda mechanically lost.

The next most important constituent of the ashes of straws that calls for particular attention is potash. While silica is considered as an impurity and of no value, the potash, on the other hand, might be utilized and turned to account. This problem is, however, as difficult to solve as that of getting rid of the silica in the waste soda lyes. If we refer to the table of composition of the ashes of straws, it will be found that the potash is very considerable in quantity, that, in fact, it ranks next to silica in this particular. It appears highest in the oat straw, rye coming next, then barley, and finally wheat. The oat straw contains more potash than silica, indeed, 2·98 per cent. of its weight. Assuming, as before, that 49 cwt. of this straw will yield a ton of bleached cellulose, the amount of potash which passes into solution for this quantity is 1·46 cwt., which represents nearly 14 cwt. of potash alum. The above barley straw would yield a very similar amount, while the rye and the wheat would yield proportionally smaller quantities.

Some years ago I made several experiments with a view to recover the potash if possible in a useful state. The separation of it from the soda is very difficult, and so far as I am aware can only be accomplished in an imperfect way by crystallization. The solubility of carbonate of potash being much greater than that of the corresponding soda salt. Of course it is practically impossible to get the potash by itself in a comparatively pure state in this way, and commercially it is too much contaminated with soda to be of much value, excepting probably in the artificial manure trade. I have, however, attempted to obtain it in the form of an alum by neutralizing the alkalies in the mother liquors, after crystallization, with sulphuric acid, and then adding sulphate of alumina and further concentrating and crystallizing, obtaining a crop of crystals. These, however, consisted largely of sulphate of soda (Glauber's salts), but undoubtedly contained crystals of potash alum.

This method, the principle of which was applied by Newlands many years ago to the recovery of potash from sugar solutions, would be costly to carry out in practice, as it involves first the separation of the silica from the recovered ash; second, the separation of the bulk of the soda from the potash; and finally, the purification of the alum. On the other hand, the advantages of being able to purify the waste lyes, together with the value of the potash recovered, would, I dare say, allow of considerable expenditure in dealing with the problem.

* An allowance of course must be made for the amount of potash present in the straw as a silicate.

IV.—FUEL, ETC.

It is always an important addition to manufacturing experience to be able to estimate from well-established data the amount of steam or coal consumed in carrying on any manufacture. The difficulties to be overcome in doing this naturally depend on the nature of the operations to be carried out, whether in fact heat is consumed in bringing about chemical reaction, or in the generation of mechanical force by any of the well-known types of steam engines; or in the process of artificial drying or evaporation. All these, namely, heat for (1) accelerating chemical reaction, (2) for generating mechanical power, and (3) for drying, are used in the preparation of straw cellulose; and the conditions of the manufacture being well defined, it is a simple matter to calculate the lowest amount of steam required to perform the various operations in the different departments of a straw pulp factory.

It is not my intention to include in this paper the various formulæ I employ to ascertain these items, as they more properly belong to another subject, but as this paper would be incomplete without reference to the fuel used to produce a ton of cellulose, I will simply state the results I have obtained by the application of these formulæ. It will be convenient to calculate the quantity of steam required for each operation and then to total the amounts.

a. Steam for Digesting the Straw.—It is obvious enough that the quantity of steam required to boil straw depends upon the temperature at which the digesting process is conducted, the proportion of caustic lye to straw being in nearly all cases about the same. The higher the pressure or temperature (for the one corresponds to the other), the more heat is required to raise it to that temperature. If, therefore, we know the respective weights and specific heats of the caustic lye, straw and boiler (wrought iron), it will be easy to calculate the total heat units required to raise them to the maximum temperature; and as the heating is done with high pressure steam, it will not be difficult, on the other hand, to calculate the weight of steam that is needed to impart this necessary amount of heat. It is on this principle, one which indeed is applicable to a great number of parallel cases and is commonly known, that I ascertain the lowest amount of steam required to boil straw.

Take the individual case above quoted, in which a charge of 40 cwt. of straw and 16,945 lb. of caustic soda lye of 10½ Tw. were boiled in a wrought iron boiler weighing 7 tons at a maximum pressure of 60 lb. above atmosphere (*i. e.*, 307° F.), there were 4,499 lb. of steam required to raise the boiler and contents to 307° F. This weight of steam represents the lowest amount that can possibly be consumed in performing the work. By a simple proportion sum, the steam needed to digest 49 cwt. or that quantity which produces a ton of cellulose can be ascertained. It is necessary to make an allowance for loss of heat by radiation which invariably takes place, but as this varies in different factories, it can only be properly estimated by direct investigation. My own experience, which is somewhat limited in this particular manufacture, is that an allowance of 20 per cent. is ample for well arranged works in which the steam boilers are in close proximity to the digesters.

b. Mechanical Power.—This is usually generated by a steam engine of the simple condensing, compound, or triple expansion type, and as the steam consumed in the development of one indicated horse power per hour by each of these types of engines is generally known, and can, in any case, be estimated with accuracy, if the total amount of power expressed in horse power required to produce a ton of cellulose be known, the steam necessary for this department can be easily calculated. In well arranged works, from 3 to 3½ horse power per hour are required per ton of pulp per week. That is to say, a factory producing 30 tons of air-dry pulp per week will require a mechanical power equal to from 90 to 105 indicated horse power generated continuously throughout the week (144 hours). This power includes the cutting and dusting, disintegration of the pulp, and, in fact, is sufficient to drive the whole machinery of the mill. Assuming a compound engine of modern construction to be used for generating this force, using say 18 lb. of steam per indicated horse power per hour, then we have

$$\frac{90 \times 18 \times 144}{30} = 7{,}776 \text{ lb. of steam per ton cellulose.}$$

c. Drying.—To ascertain by calculation the amount of steam to dry the wet web of pulp is not so simple, although this case is well defined and can be expressed by a formula of very general application. The wet web of pulp, which contains about 55 per cent. of water, 50 per cent. of which must be driven off, is passed over a series of drying cylinders heated by steam of from 8 to 10 lb. pressure. Having regard to the special circumstances prevailing in such a system of drying, it may be fairly assumed that the water in the wet web is evaporated as steam of 212° F.; and that the water condensed within the cylinders is ejected from them at a temperature corresponding to the steam pressure within, viz.: 8 to 10 lb. per square inch above atmosphere. The steam condensed within the cylinders is a measure of the water evaporated. If we know the amount of water to be evaporated from the wet web per ton of air-dry cellulose made, it is not difficult to estimate the necessary quantity of steam to perform this evaporation. The water to be driven off, as above indicated, may be fairly taken at one ton (2,240 lb.) per ton of cellulose, and the quantity of steam condensed to water of temperature 240° F. (10 lb. steam pressure) inside the cylinders to evaporate this water, *i. e.*, convert it into steam at 212° F. and under atmospheric pressure, is 2,647 lb. In this, as in the first case mentioned, an allowance must be made for loss of heat by radiation. After carefully considering similar cases and making tests, I have come to the conclusion that 15 per cent. of the calculated quantity is sufficiently large to cover this loss, in all cases where there are few stoppages in the drying, and where the ends of the drying cylinders are protected by non-conducting materials.

Collecting these results, we then have per ton of cellulose:

	Lb.
Steam for digesting, including loss of heat by radiation, 20 per cent.	6,613
Steam for developing the mechanical power	7,776
Steam for drying, including allowance of 15 per cent.	3,044
Total steam required	17,433

To convert this into coal, it is necessary to know how much water is evaporated in the steam boilers per lb. of coal burned. Assuming this to be 7 lb. water, the above 17,433 lb. of steam represents 24·9 cwt. of coal. This, according to my observations, is rather lower than that usually used per ton of straw cellulose made, excluding the coal used for soda recovery, but I venture to think it fairly represents what can be done, and is a direct measure of the possibilities in the hands of pulp makers with regard to the economy of coal.

DISCUSSION.

Mr. A. Smetham said he had been interested personally in the distinctions which Mr. Beveridge drew in regard to the different straws and their value to the paper maker, and that more particularly because in their use for feeding purposes various straws had distinct values. He noticed in the tables by Muller that the percentage of cellulose was found to vary to a very large extent, whereas with Mr. Beveridge's estimates the percentages for his practical purposes by the bisulphite tests for the cellulose were, if not identical, very nearly so, in the straws from the various sources. It had been puzzling him how to account for those differences. Doubtless in paper making a certain quantity of the actual cellulose would be destroyed, partly in bleaching, and it might be for those reasons that the differences existed. He was not aware what process Muller used for the estimation of the cellulose, but taking his figures, and assuming for the moment that Muller had used a process which he (Mr. Smetham) thought was common with nearly all agricultural chemists, viz., that of boiling with two per cent. solution of sulphuric acid, washing with water, then boiling with a two per cent. solution of caustic potash, washing again with water, then with a dilute cold solution of hydrochloric acid, and washing free from acid, then with alcohol and ether, and finally drying. It seemed difficult to believe that the quantity of cellulose, as stated by Mr. Beveridge, would really be above that in the table, the more especially as he noticed that the strength of the caustic soda used by the paper maker was something under one-third per cent. It was true that the digestion went on very much longer in paper making than in the laboratory (for half an hour) with the caustic; in practice, according to Mr. Beveridge's tables, it went on under pressure at a temperature of 307° for four hours, and possibly therefore there might be gradual loss. He imagined that the process in the laboratory would have been quite as drastic as the process of the paper maker, and it was certain that Muller's results, so far as oat straw was concerned, were in accordance with what was found when the straw was used for feeding purposes. The percentage of cellulose in straw depended very largely on the period of growth, and it was possible that the differences between Muller and Mr. Beveridge could be accounted for in that manner. Certain it was that the oat straw was more valuable for feeding purposes than wheat straw. He would be interested if Mr. Beveridge could throw some light upon that difference, and it would also be interesting to him if Mr. Beveridge would sketch in a rough way the process which he used on the laboratory scale for estimating the cellulose by the bisulphite test.

Mr. Bateson remarked that there was a process brought forward to add bicarbonate of soda and precipitate silica. Was this process likely to pay? The table exhibited showed that the percentage of cellulose varied a great deal, according to the quantity of caustic soda added. What was the reason of this variation? With regard to the recovery of potash in the residual liquors, would not the potash accumulate, and was there not a point where it would be taken away advantageously?

Mr. Beveridge said the fact was the laboratory method which he had used for estimating the cellulose was that formulated by Muller, and did not involve the use of caustic potash at all, but was substantially that indicated in the body of his paper—namely, treating the sample first with water, then, after drying, with alcohol and benzol, and finally with successive baths of ammonia and bromine water, an allowance being made for mineral matter in the cellulose residue. It was therefore distinct from the method mentioned by Mr. Smetham, which included digesting the sample in a two per cent. caustic potash solution, whose solvent action was much greater than that of ammonia. It was five years ago since he (Mr. Beveridge) tried Muller's method, and he confessed he was not so well acquainted now with the details as he ought to be. He threw over the process at that time because he found it did not give him a correct idea of the amount of cellulose available for paper making, and, as a manufacturer, preferred the bisulphite method instead. This consisted in digesting the straw for six or seven hours in a bisulphite of soda solution containing about 2·75 per cent. total SO_2, about 55 per cent. of which existed in the free state, the other 45 per cent. being combined as monosulphite. The temperature employed corresponded to a steam pressure of 60 or 70 lb.

above atmosphere. The apparatus he used consisted of a strong tube of antimonial lead inserted in a small wrought iron boiler containing water. This boiler, which was heated by gas, acted as a steam jacket. The sample and bisulphite solution were placed within the antimonial lead tube. While managing a large sulphite wood pulp plant on the Thames, where all the pulp boilers were stationary, he had used another and more convenient and reliable method. This consisted in simply placing the sample of straw and the bisulphite solution in a cylindrical leaden dish, sealing it up with the blowpipe excepting a small pinhole in the cover, and placing it inside one of the large wood pulp boilers. The sample was "digested" under the same conditions of time and temperature as the wood within the boilers. In this way he got excellent results. He had varied the percentage of SO_2, within certain limits, and had found that the yield of cellulose was not affected by a reasonable excess of SO_2 as bisulphite. The percentage of SO_2 must not, however, be too high, otherwise he thought hydrocellulose was formed. These results were uniformly lower than the percentages given by Muller, and if the latter were correct, he could not understand why paper makers did not get a higher yield than 40 per cent. air-dry pulp by the most careful manipulation in the factory.

He believed that some substance was included in Muller's percentages of cellulose as given in the table which could not rank as cellulose. The fact that, in the instance quoted by Roth, in which a yield of 50 per cent. air-dry pulp was obtained, 7 cwt. of bleaching powder were required to bleach 1 ton of this pulp plainly showed there was some substance present which required inordinate oxidation. He thought on the whole Muller's results were too high. The percentage of cellulose given by Muller for the oat straw agreed more closely with his own, but that given for wheat and barley was too high according to his experience. Referring to the points raised by Mr. Bateson, the potash could not be allowed to accumulate in the liquors unless the silica was periodically removed. The amount of this silica was so great that where the percentage of soda recovered was anything like 70 per cent. of the amount put into the pulp boilers, after the recovered ash was used twice or thrice, it became practically worthless for further use for digesting. It was obvious, therefore, that the silica must be removed before the potash could be allowed to accumulate to any great extent. The separation of this silica as a practical manufacturing operation was indeed a very difficult process, but if this could be adequately done, the only way, as far as he knew, in which the potash might be utilized was by the method mentioned in the paper, viz., by separating the carbonate of soda from the carbonate of potash by crystallization, and, after neutralizing the mother liquors with sulphuric acid, adding sulphate of alumina to get a potash alum.

SEWAGE DISPOSAL WORKS, CANTON, OHIO.

By L. E. CHAPIN, member of the Civil Engineers' Club of Cleveland.

THE city of Canton, with a population of 32,000 and an area of 7 square miles, has a storm water system of sewers for the removal of all storm water, and into this system no household wastes of any description are admitted. These storm water sewers discharge into the two branches of the Nimishilla Creek by the most direct and accessible routes.

For the removal of household wastes a separate system of sewers is used, into which no rain water or elevator water is discharged. The general plan of this sanitary system contemplates the sewerage of the entire city by systems of mains, submains and laterals, varying from 6 to 20 in. in diameter, and of vitrified salt glazed sewer pipe. The minimum grades range from 1 ft. in 100 for the 6 in. laterals to about 0·2 ft. in 100 for the 20 in. main sewers.

All laterals are provided at their upper ends with automatic flushing tanks, and a frequent and regular cleansing of all sewers is thus insured. The flush tanks are in the main equipped with the Rhodes-Williams automatic siphon. Some sixty siphons of this pattern are in use, as well as eight Field-Waring siphons and one Rosewater siphon.

These siphons are so supplied as to flush at intervals of from eight to twenty-four hours, depending upon the number of house connections made with each individual sewer. The water discharged at each operation of the siphon varies from about 250 gallons in the 5 in. siphon to about 350 gallons in the 6 in. siphon.

In the maintenance of a sanitary system embracing some seventeen miles of sewers, no trouble has so far been experienced in keeping the entire sewer system, both laterals and mains, clean and free from any adhering organic matter or deposits by the use of this system of flushing.

The seventeen miles of sewers are entirely in the central part of the city, known as Sewer District No. 3. To complete the plan for the entire sewering of the city involves the future construction of sanitary sewers in Sewer Districts Nos. 1 and 2. The mains from these districts are designed to discharge into the main sewer of District No. 3, at the head of what is known as the trunk sewer, and provision is thus made for the removal of all organic wastes through the trunk sewer to the City Sewer Farm, located on the main branch of the Nimishilla Creek, two miles south of the city and outside the city limits.

The sewer farm, embracing 28 acres of land, was originally purchased as land for the outlet, and it was intended that on this land some method of sewage purification should be perfected and carried into operation. Of these 28 acres, however, only about 13 are available for purification by land treatment, the balance being low bottom land annually flooded by the spring freshets of the stream.

METHODS OF PURIFICATION.

The subject of sewage purification was early brought to the attention of the city authorities by the complaints made by riparian owners below the outfall of the trunk sewer. An investigation of the available methods of purification developed the fact that the ground owned by the city, as well as all other land in the vicinity, was of a formation poorly adapted for purification by broad irrigation or intermittent filtration. The area of land requisite to provide for future requirements by these methods of purification could not be had except at great expense, it being then considered that for broad irrigation there would be required some 300 acres of land, the first cost of which, including the preparation of 120 acres to adapt it for the purpose, as well as the expense of a pumping plant, buildings and force main, would result in a total expense of $155,123, from which the annual expense was estimated as follows:

Interest on $155,123 at 4 per cent....	$6,244 96
Cost of pumping per annum.........	1,942 40
Total expense per annum........	$8,187 36

For intermittent filtration there would be required at least 50 acres of land, the preparation of 13 acres for present requirements by sloping and underdraining, a pumping plant and buildings, and a force main for lifting the sewage. The estimated total cost of all this was $45,482, and the annual expense, including interest and cost of pumping and operation, $3,861.30.

The tract owned was, however, so located that the sewage could be brought to it by gravity, and the expense of pumping was thus obviated. Inasmuch as a large area of land would be required for broad irrigation, and as it was almost impossible to obtain for intermittent filtration a suitable tract of ground within reasonable distance, it was deemed best to adopt the method of chemical purification for the Canton city sewage, the works to be built on the city sewage farm and the sewage brought to it by gravity.

For the purpose of arriving at the probable cost of such works, a plan, report and estimate of cost were had from Samuel M. Gray, of Providence, Rhode Island. The estimated cost of the works complete was about $38,000.

Before proceeding with the construction of the works a special committee of the city council was appointed to visit towns in the Eastern States where purification works had been constructed, and report the result of their investigation to the council for further consideration.

This committee visited the several prominent purification plants then in operation in Massachusetts, New York and New Jersey, and reported favorably upon the method of chemical precipitation recommended by Mr. Gray as being the best and most practicable, and recommended that immediate steps be taken to carry out his plans.

The committee, convinced of the ultimate success of the works, and believing that the effluent reaching the creek would be in no manner objectionable to the owners and residents of the lower creek valley, suggested certain modifications in the design of the works. Upon the adoption of this report the board of sewer commissioners instructed the city engineer to prepare an amended plan for chemical purification works in accordance with the ideas suggested by the visits of the special committee in the East; and, after several plans had been prepared and carefully studied, a plan of precipitation works somewhat similar to that built by the city of Worcester, Mass., was adopted, specifications prepared and proposals ordered.

For funds to carry on the work the city of Canton had authority, previously conferred by act of the State Legislature, to issue $25,000 of sewage disposal bonds; and within this amount it was deemed advisable to limit, so far as could be, the cost of the works complete and in working order.

Specifications were prepared and bids received, and contracts were awarded separately for the grading, for the construction of the inlet sewer, masonry, precipitation tanks and effluent sewer, for the building and for the machinery and appurtenances.

Ground was broken in July, 1892, and the greater part of the brick masonry and connecting sewers was built during the same fall and the early winter. The building was erected during the winter and the machinery and appurtenances in the spring. The entire plant was in running order by May 15, 1893, and the total cost was $26,483.76.

THE PLANT.

The plant is contained in a heavy frame building on a brick foundation, and comprises a boiler and pump room, 28 by 30 ft., lined with brick; a chemical mixing and press room, 30 by 40 ft.; and a chemical store and slaking room, 30 by 40 ft., located above the mixing room.

The four precipitating tanks are each 50 by 96 ft. in plan. When filled they have an average depth of 4·75 ft.; the sewage being 3 ft. 10 in. deep in the shallowest and 5 ft. 9 in. in the deepest parts. The capacity of each tank is 171,100 gallons.

The sludge is lifted by a horizontal duplex Voisard sludge pump having steam cylinders 7½ in. in diameter, with 5 in. plungers and 10 in. stroke. The suction pipe connections are so arranged as to take either sludge from the sludge cistern or clear water from the clear water well, and the discharge connections are such that the sludge may be forced into the filter press or through a line of 2½ in. pipe outside of the building to a sludge gravel bed, or clear water pumped from the clear water well to an overhead storage tank within the building.

The feed pump is a duplex, 4½ by 3 by 5, so arranged that it can be used either for boiler feeding, for filling the overhead supply tank, or for pumping water under pressure for cleansing purposes about the building and for washing down the sides of the tanks after the sludge is removed.

Steam is generated in a horizontal tubular boiler, 54 in. in diameter and 12 ft. long, placed in a substantial brick setting with full arch front. The smokestack is of plate iron and 53 ft. in height.

The chemical mixers are of wood and elliptical in form, with diameters of 5 and 9 ft. and 7 ft. high. They are operated by an automatic vertical engine.

The filter press is a sixty-section chamber Bonnot press, each chamber being 29 in. in diameter and equipped with rubber gaskets to obviate the tearing of the filter cloths. The press has a traveling head with a hand-tightening gear and quick opening arrangement, with the necessary relief valves, blow-off connections and air chamber.

Within the sludge cistern is located a No. 5 pulsometer pump, the connections of which are so arranged that it can be operated from the boiler room, lifting the sludge from the cistern and discharging it either into an open tank located outside of the pumping room or through a line of 2½ inch pipe onto a sludge gravel bed. This pump is designed to be used as an auxiliary for lifting the sludge at times when the sludge forcing pump is in need of repairs.

In case the suction lift without foot valve should at any time prove hard to maintain, the sludge can be supplied by gravity from the open tank to the suction chambers of the sludge forcing pump.

Water for all steam and mixing purposes is drawn from the effluent channel, and is pumped into an overhead storage tank holding 2,200 gallons. From this tank it is drawn off as required.

TREATMENT.

The sewage is diverted from the main sewer into the inlet sewer at a manhole, just above the city farm. The inlet sewer enters the building at one end under the boiler room floor, and there enlarges into a screening chamber provided with gates and screens for the removal of obstructive matters. Thence it passes through an inlet channel 4 ft. in width to the four tanks located outside of the building.

The lower end of this inlet channel connects with a double circulating channel located midway between the four precipitating tanks, two of which are placed on each side of the channel.

At the point where the sewage enters the building it receives a charge of milk of lime from the lime mixer, and where it leaves the building a solution of sulphate of alumina is added. The sewage, then passing down the inlet channel, is agitated by baffle boards within the channel. This insures a thorough mixture of the precipitating agents with the crude sewage before the latter enters the precipitating tanks. On reaching the precipitating tanks the sewage so charged enters the first tank and passes through it to the further end. It is then deflected back and re-enters the circulating channel, from which it enters the second tank. Thence, by the same method of circulation, it passes into and through the third and fourth tanks to its exit over the aerating steps of the effluent chamber, and thence into and through the effluent sewer to the point of outfall in the Nimishilla Creek.

The chemicals used, lime and sulphate of alumina, are delivered by wagon into the second story of the mixing room, and are there stored in their respective bins. The proper charges of lime are weighed out at regular intervals into a slaking tank located on this floor, and, after being slaked with a large surplus of water, are passed down into the lime mixer on the first floor, while the sulphate of alumina, weighed out in the requisite amounts, is dumped directly into the top of the chemical mixer, which is also on the first floor. Sufficient water is added to both the lime and alumina solution to facilitate their easy and uniform discharge into the crude sewage.

These lime and chemical mixers, as already stated, are elliptical in plan, having diameters of 5 and 9 ft. and 7 ft. in height. Each mixer has two vertical shafts carrying beater arms and revolving at the rate of about 20 revolutions per minute for the purpose of maintaining a homogeneous mixture. The agitating power is obtained from a 16 horse power vertical engine, which drives the mixers by belting. From these mixers the solutions are discharged through 2 in. pipes controlled by gate valves, so that the quantities discharged are easily regulated.

The precipitation process is such that approximately one-half of the suspended matter taken out is deposited in the first tank and about one-fourth in the second tank, while the balance is equally distributed between the third and fourth tanks. The sludge is removed three times a week from tank No. 1, twice a week from tank No. 2, every five days from tank No. 3 and once a week from tank No. 4. This method of sludge removal gives, as shown by experiment, a uniform daily amount of sludge for pressing and the best results in precipitation.

To remove the sludge from the bottom of each tank the tank to be cleansed is cut out from circulation, the sewage then passing by it and into the other three tanks in rotation. After standing for some two hours, the supernatant water from the tank so cut out is decanted by means of a floating skimmer pipe into a clear water sewer lying beneath the circulating channel and discharging under the lower steps of the effluent chamber and thence passes into the effluent sewer.

When the floating skimmer pipe reaches the accumulated sludge in the bottom, the sludge is raised to the surface. Then by means of a 12 in. gate valve, the accumulated sludge is drawn off into a sludge sewer located under the circulating channel and discharging into a sludge cistern placed beyond the tanks and just outside of the pumping room.

From this cistern the sludge is lifted by the suction of a duplex plunger pump with ball valves, and is forced into a sectional filter press under a pressure of about 100 pounds per square inch. From this press the exuded water passes out through the filter cloths and into a gutter beneath and thence through a drain to the inlet sewer, the solid matters being retained within the press in the form of cakes, and when the press is emptied the cakes fall into a car below. This car, when full, is run out of the building on a track, which passes across the tanks by a bridge to the sludge cake dumping ground.

About 8 grains of lime and 1·6 grains of sulphate of alumina have been used per gallon of sewage treated. Owing to the large capacity of the precipitating tanks, these proportions give a very satisfactory effluent. As the other districts come to be sewered and the quantity of sewage to be treated increases, a larger amount of chemicals can be added, and thus an effluent can be maintained such as will satisfy all present and future requirements.

Should the creek water be used as a public water supply, the effluent from the works can be further treated, without pumping, by intermittent filtration on the city's lands adjoining the works on the west side. The absence of any suspended matters in the present effluent would enable a comparatively large

* From the *Journal of the Association of Engineering Societies*. Read December 12, 1893.

amount of effluent water per acre to be applied to the land prepared for intermittent filtration.

The total amount of sewage treated daily averages 880,000 gallons, from which are obtained, approximately, four tons of sludge cake per day.

The raw sludge, as it is drawn into the sludge cistern, contains, approximately, 95 per cent. of water, and the cake obtained from filter pressing contains, approximately, 58 per cent. of moisture. About four presses of sludge per day are obtained, each press making 60 cakes of an average weight of 33½ pounds.

Thus far no attempt has been made to sell the sludge cake, but no difficulty is found in having the cake promptly removed from the dumping ground by farmers desiring it for fertilizer.

The average time consumed in running out a press of sludge cake is, approximately, two hours, which includes the filling of the press, the emptying and the locking up of the press ready for refilling; but the operation has been performed in 55 minutes. The rapidity of operating depends upon the texture of the filter cloths, a closely woven jute material of about 15 threads to the inch being found most satisfactory, although not as durable as a canvas having 40 threads to the inch, such as is used at present.

The life of canvas sacks approximates two months, or 200 presses; while the life of jute sacks runs somewhat less, depending upon the character of the sludge and largely upon the diameter of the central openings through the filter chambers, the larger openings giving less resistance to filtration and much better service.

The use of a duplex pump in filling the filter press has so far proved highly satisfactory. The pump, being equipped with ball valves of hard rubber, passes freely large amounts of thick and stringy matter without the slightest choking, and responds promptly to the varying requirements of the press for sludge.

The monthly expenses for maintenance are as follows:

	Per month.
One engineer in charge of the works	$60 00
One helper	40 00
One night engineer and watchman	40 00
Coal, 20 tons	31 00
Lime, 15 tons	42 90
Sulphate of alumina, 3 tons	60 00
Oil and waste	8 00
Filter cloths	10 00
Miscellaneous	3 10
Total per month	$295 00
" " year	3,540 00

This amounts to 23 6 cents *per capita* per year with a population of 15,000 persons in the district connected with the sewers, or $11.19 per million gallons of sewage treated.

For an increase in the amount of sewage treated the cost for attendance, coal and other supplies would remain the same, and the additional cost would practically be only that of the additional lime and alumina required.

During the winter months, and at times of freshets and high water, only so much sewage will be passed through the precipitating tanks as will suffice to protect them from frost, chemical treatment will be entirely omitted, and only sufficient help will be retained at the works to properly care for them. In this manner the annual expense will be reduced to a figure materially below that named.

The lowest observed temperature of the sewage at the outfall in the coldest weather of the winter of 1892–93 was 46° Fah., and at the same time the city water supply was at a temperature of 34°.

The lowest temperatures observed during the recent cold weather, when the temperature of the external air was 16° Fah., was 50° for the sewage at the mouth of the inlet sewer, 48° where it enters tank No. 1, 49° at the farther end of tank No. 1, 47° in each end of tank No. 2 and in tank No. 3, 46° in tank No. 4, and 45° in the effluent water at the foot of the aerating steps, showing a total loss of temperature of 5° in the passage of the sewage through the tanks.

On the basis of the same decrease in temperature for the colder weather in the winter, when the temperature of the external air stands below zero, it is unlikely that the temperature of the effluent for continuous circulation will fall below 41° or 40° Fah.

Several analyses have been made of the sewage and of the effluent, but the conditions under which the samples were taken were such that the results obtained by the analyses thus far made do not show the true working of the plant, for the samples have been taken within too limited a period of time, and too long a time was allowed to intervene between the collection of the samples and their analysis.

Generally speaking, the analyses show that, using lime alone, and at the rate of 1,100 pounds per million gallons of sewage, 59 per cent. of the organic matter contained was removed by the process of treatment. No analysis of the effluent has been made since the use of sulphate of alumina, in addition to the lime, was adopted.

The indications, so far as one can judge from an inspection of the effluent, are that by the addition of 200 pounds of sulphate of alumina per day a much higher degree of purification is attained.

The analysis of the lime used shows the following composition.

	Per cent.
Calcium oxide	84·7
Magnesium oxide	1·5
Ferric oxide	5·8
Moisture, carbonic acid and undetermined	8·0
Total	100·0
Lime, soluble in water	82·5

This is a local lime, costing 10 cents per bushel of 70 pounds delivered in the bin at the works.

The sulphate of alumina, so far used, is represented as containing insoluble matter 10 per cent., and sulphate of alumina 44 per cent. It costs, in a pulverized condition, about $20 per ton in car load lots delivered at the works.

Investigations are now in progress to determine the suitability of other grades of sulphate of alumina, with the idea of obtaining, at the lowest cost, that most suitable for the process.

The operation of the works has continued to be highly satisfactory to the citizens of Canton and to the riparian owners of the lower creek valley, and no odors of any nature are discernible at any time about the plant. The authorities are well satisfied with the results of chemical precipitation for the disposal of house sewage.

TUBERCULIN AND BOVINE TUBERCULOSIS.

By E. A. DE SCHWEINITZ, Ph.D., Biochemic Laboratory, Bureau of Animal Industry, Washington, D. C.

IN the SCIENTIFIC AMERICAN SUPPLEMENT for April 28, 1894, Mr. H. G. Wolcott, New York State Commissioner of Health, has an article on bovine tuberculosis, in which he makes the statement that the department in Washington has the formula for the manufacture of tuberculin, but that this and the imported tuberculin do not give the same febrile reaction. This statement is misleading, and deserves correction, because it is not warranted by facts.

About three years ago I began the preparation of tuberculin for use in diagnosing disease in cattle, following in general the method as indicated by Koch in his early articles on the subject, modified by some slight changes which were advantageous to the work. Before making any extensive use of this tuberculin, comparative tests were made with the Koch imported article, with results which showed the tuberculin as manufactured here to be equally reliable. These experiments were carefully conducted, and the comparative results upon a herd in which all the animals were eventually killed will shortly be published by the bureau. All the tuberculin prepared in this bureau has been either made by me personally or under my direct supervision, and none has been sent out for use from this laboratory unless its strength and reliability had been first tested upon tuberculous guinea pigs and tuberculous cattle.

At the request of the State Board of Health of New York, two small lots of tuberculin of known reliability were forwarded to them for use. What disposition was made of this material I do not know, as the board failed to make any report upon its use. When the tuberculin left my hands it was reliable in every way. During the three months beginning January 1, 1894, tuberculin has been sent to twenty-four States, in quantities sufficient to test about two thousand five hundred animals. Some of the parties have used the Koch tuberculin at the same time, and in no instance have any unsatisfactory reports reached this office. As Mr. Wolcott states, tuberculin can be reliable in *skilled* hands only, which means, not only the hands of one who has used tuberculin a number of times, but one who is thoroughly familiar with the literature on the subject. This is considerable and covers a number of experiments, both in this country and abroad, which indicate many idiosyncrasies, both in animals and reactions.

The earliest results with tuberculin showed that there was always a difference in the rise of temperature between the first and second injections on the same animal, that if the first temperature was high, the second would often be lower by several degrees, or in some instances the second injection would give no reaction. Again it would occasionally happen that the first injection would cause only a slight rise of temperature, while the second would give a very marked rise. These results were irrespective of the tuberculin. The interval of time between the first and second injection with the tuberculin, in order that the second injection can be considered at all reliable, should be at least one month, and even after this time the second injection will occasionally be unreliable.

In certain cases, too, the tuberculin possesses some undoubted curative properties, and these and other facts, as well as the idiosyncrasies of the animals, must be taken into account in drawing conclusions.

The value of tuberculin as a diagnostic agent is undoubted, and by its use it will be possible eventually, if not to entirely eradicate, at any rate to control and limit the disease among cattle, and thus indirectly in man.

The active principle of tuberculin is sometimes incorrectly called a ptomaine, and statements are often made that nothing is known of its true nature. Ptomaines is a name given to a class of substances that are like the vegetable alkaloids in their constitution and many of their properties, and this name was first used to indicate the alkaloidal substances that were derived from the putrefaction of animal matter. A number of different germs produce alkaloidal substances and in that sense ptomaines, but these are not the only products.

The active principle of tuberculin, however, has been proved to be not a ptomaine, but a substance belonging to the albuminoids, probably the nucleo-albumens. The same appears to be true for the active principle that is produced by the glanders bacillus, the diphtheria, tetanus, hog cholera, swine plague and other germs. Our knowledge at present does not give us a clear insight into the nature of these albuminoids, but is sufficient to exclude the substances from the ptomaines proper, unless the word is used to signify bacterial poisons in general.

The Bureau of Animal Industry, under the direction of Dr. A. E. Salmon, furnishes to State boards of health and experiment stations a tuberculin reliable in every respect.

By its aid national legislation and State co-operation can do much to rid the country of one of the most dangerous of diseases for animals and man.

TRIKRESOL.

UNDER this name a purified mixture of ortho-, meta-, and paracresol has been introduced for surgical purposes. It is a clear, colorless liquid, having an odor like creosote, and boiling between 185° and 205°. The specific gravity is from 1·042 to 1·049 at 20° C., and it is said to be almost, if not entirely, free from phenol. The purification of this product from neutral hydrocarbons has been carried out so that the purified product will dissolve in water to the extent of from 2·2 to 2·5 per cent., which is amply sufficient for its application in surgical practice, for which purpose a solution containing from 0·5 to 1·0 per cent. is strong enough, on account of the great disinfecting power of the cresols. By means of this purification it is thought that the necessity for adding emulsifying agents to cresol in order to obtain sufficiently strong solutions will be done away with. Gruber's determinations of the solubility of cresols in water gave the following results (*Archiv. f. Hyg.*, 17):

	Per cent.
Orthocresol	2·50
Metacresol	0·53
Paracresol	1·80
Mixed cresols from toluidine	2·20
" " " tar oil	2·55

TABLE OF CONTENTS.